Evaluation of Chemistry for Our Future

Report on the first year of the evaluation (2007 – 2008)

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Appendix C: Progress of Strand 3.2: Chemistry for All project partners

Executive Summary

Introduction

This executive summary presents an overview of the findings from the first full year (September 2007–October 2008) of the evaluation of Chemistry for Our Future (CFOF) which is being undertaken by the National Foundation for Educational Research (NFER) on behalf of the Royal Society of Chemistry (RSC).

Chemistry for Our Future is a £3.6 million (funding total for this phase) pilot programme funded by the Higher Education Funding Council for England (HEFCE). The current phase has been delivered over a two-year period by the RSC in partnership with universities, schools and other organisations. The key objectives of the programme are to:

- work with schools, colleges, industry and higher education institutions (HEIs) around the country promoting chemical sciences as a stimulating and profitable career route
- raise the aspirations of school pupils and widen and significantly increase participation in HE chemical science courses, particularly for groups under-represented in higher education, thereby sustaining chemistry as a strategic subject
- improve liaison and hence understanding across the key educational interfaces (primary, secondary, tertiary, HE and employment)
- investigate the best use of university chemistry laboratories and staff to deliver effective and efficient use of resources and provide good value for money
- review and develop HE teaching and learning (curriculum development) to ensure fitness for purpose with regard to educational outcomes for student participants and the skills and training needed by employers in both the chemical and non-chemical sectors
- explore opportunities for progression from vocational routes
- provide a cohesive set of opportunities for teachers and students by working with the wide range of organisations and initiatives already involved in STEM promotion activities
- raise awareness of the key role chemists play in the development of a sustainable future for all and demonstrate that chemists provide many of the solutions for the global challenges faced in the 21st century.

CFOF has four key strands:

- Strand 1: University and Industry Outreach, including further roll-out of the widening participation project, Chemistry: the Next Generation (CTNG)
- Strand 2: Supporting Key Educational Interfaces – a Teacher Fellowship Scheme
- Strand 3: Higher Education Chemical Sciences Curriculum Development
- Strand 4: Widening Access to University Laboratories.

There are also two cross cutting themes:

- Theme 1: Careers
- Theme 2: Sharing Good Practice.

Aims and objectives of the evaluation

The NFER's evaluation aims to evaluate the progress and impacts of the CFOF programme. Over the course of this year, we have explored: the progress to date of each of the four strands; the outcomes and impacts for school pupils, university students, teachers and higher education institution (HEI) staff; what works well; the main challenges; additionality; and future developments.

Methodology

The evaluation methodology recognises that this is a pilot programme, spanning two years, and that any change programme takes time. The evaluation has used a mixed-methods design including: desk-research; meetings; interviews; focus groups; case studies with schools and universities; the development of standard evaluation tools for internal administration, such as survey questionnaires for pupils and teachers; and the tracking of a small sample of pupils (250) to establish ongoing and longer-term impacts. Through these methods, teachers, academics, pupils, undergraduates and strand managers have been consulted.

Overarching findings

How effectively has CFOF been managed?

CFOF has been well managed by the RSC and their partners. A particular area of success has been the way that programme management has encouraged **effective sharing and dissemination of learning and good practice**. The sharing has included what is working well, and, importantly, what is proving difficult or challenging. A spirit of collaboration and openness has been engendered throughout the whole management of CFOF, **particularly within strands**, and from operational management level to Project Advisory and Steering Groups.

In addition, there is evidence of collaboration **between strands** particularly where **key conduits** exist – such as key personnel (some of the teacher fellows have been instrumental in this), institutions involved in a number of strands, and through the Strand 3 gathering days where representatives from other strands have also been present. A focus on **greater networking between the strands** may help to share and disseminate learning and good practice further and achieve an even more integrated programme.

What are the impacts and outcomes?

For school pupils

The evaluation data suggests that CFOF has resulted in positive impacts on pupils, particularly on their **chemistry knowledge and practical skills**, **awareness of higher education**, **understanding of the relevance of chemistry**, and their **enjoyment** of chemistry. Through participation in CFOF enrichment and enhancement activities, pupils have learned about how chemistry is used and applied in ‘real’ life and have a greater understanding of the possibilities associated with the subject, raising their aspirations in relation to chemistry. For an **encouraging minority**, the activities do seem to affect their **future intentions** towards studying chemistry further and choosing chemistry as a career.

However, **greater emphasis may still be needed in CFOF enrichment and enhancement activities on chemistry careers** and the various routes into the discipline, as more modest impacts were evidenced in terms of pupils' understandings of chemistry courses in HE and chemistry careers.

The survey findings highlight the importance of enabling pupils to experience a **number and range of different chemistry interventions**. Pupils who experience a number and range of chemistry interventions and activities report stronger impacts on their attitudes towards chemistry and their future intentions to take chemistry further as a subject or career than those who have experienced only one activity.

Consideration may be needed as to how to **strengthen the impacts of CFOF activities on female pupils**, who generally report less prevalent impacts. The evaluation data also provides support for the targeting of CFOF activities towards younger age groups, as impacts tend to be slightly stronger for key stage 4 pupils (i.e. years 10 and 11), than key stage 5 pupils (i.e. years 12 and 13) who have, to a greater extent, made their future study and career decisions.

For undergraduates

Hard data is available to suggest that some CFOF activities have resulted in **improved attainment** for undergraduate chemistry students, due to interventions that have targeted and developed their knowledge and practical skills. This is the case in Strand 3.1, although not necessarily the case for context-based and problem-based learning (CBL/PBL) approaches in Strand 3.2. Improved attainment is not necessarily a key driver for undertaking CBL/PBL. Rather, the development of important transferable and employability skills and understanding of chemistry in context underlies CBL/PBL, and outcomes around these are demonstrated by Strand 3.2.

There is also evidence that CFOF activities are having positive impacts on the **retention of chemistry undergraduates**, due to a smoother transition from school to university aided by curriculum and pastoral support interventions targeted at first year students.

Undergraduates have also gained softer skills though their participation in the CFOF activities, including **transferable skills** in such areas as group work, presentation, independent learning, report writing and critical thinking – all important and desired ‘employability’ skills. They have expressed increased **motivation and interest in chemistry**.

For teachers and schools

Teachers involved in CFOF have benefited particularly in terms of the development of greater and **improved links and relationships between schools and universities** as well as **enhanced access to resources**. Teacher involvement in CFOF also impacts positively on teachers’ **capacity to support and advise pupils** in relation to chemistry further study and careers, providing greater insights to chemistry in higher education and relevant contacts beyond the school phase. Teachers have also gained **new ideas** and resources from their participation in CFOF activities to aid their chemistry teaching and practice.

Schools’ involvement in CFOF has resulted in a positive impact on the **profile of chemistry** and science in their school. Impacts on teachers from participation in CFOF may be stronger for those teachers who have less experience and/or are seeking to enhance their chemistry knowledge and practice or develop their departments. Senior management staff in schools should consider **which staff might best benefit** from these professional development opportunities.

HEI staff and institutions

Across the strands of CFOF, considerable positive outcomes have been reported for universities and university staff. In particular, university personnel have acquired an **enhanced understanding of school curricula, practices and student capabilities**, which in turn help them to **improve the delivery and effectiveness of their undergraduate teaching and outreach activities**.

Other benefits for universities include broader and stronger **relationships with schools**, **student recruitment and retention**, and professional development opportunities for staff. There has also been **increased partnership working and collegiality** in the sharing of knowledge and experience between institutions, e.g. school to university, and university to university.

What works well?

For school pupils

Activities work well for pupils when they **balance practical** work with theory, include **hands-on** and **collaborative** work, and are **relevant** to chemistry at work and chemistry in everyday life. It is the quality of the activity and experience that is rated (e.g. the **equipment**, help from undergraduates), rather than necessarily its location (although for some pupils, being in a university environment is important).

For undergraduates

Activities work well for undergraduates when they provide **support** in two key areas: i) in their **chemistry learning**, this includes through innovative curriculum and support materials, group work, and directing teaching and learning at student needs; and ii) **transition**, including through new induction programmes and facilitated opportunities to get to know each other in their new environment.

For teachers and HEI staff

Across the strands, activities work well when there is **teacher involvement** such that they gain ideas for the classroom, and resources for future use. Teachers appreciate activities that are **flexible and tailored** to schools' needs. Again, the quality of equipment and facilities are rated highly.

Relationships and links between teachers and HEI staff are best forged through **face-to-face** activity and in a **culture of openness**. Both formal and informal approaches work well when both parties learn from each other. For example, **demonstrating or modelling** new approaches works well in curriculum development and sharing of particular practice. The **informal exchange of ideas** through an e-mail network engages teachers.

As a theme across all activities, and for all participants, **adequate preparation** prior to activities being delivered is important. Examples that have worked well include preparation time for teachers in Strand 1 prior to activities, and the use of pre-induction materials in Strand 3.1.

Participation in CFOF by teachers and HEI staff seems to work best when they have **dedicated time** for the planning and delivery of activities.

What are the challenges?

A number of challenges have been experienced across the strands. Some have been addressed as the programme has developed. However, to aid the continued development of CFOF, the challenges highlighted here should be further considered:

- the **timing and timetabling** of enrichment and enhancement events for pupils/students – as this has an impact on attendance
- the need for adequate **lead-in time**/preparation time prior to the delivery of activities – e.g. for schools to prepare for a university visit, and for academics to prepare to CBL/PBL teaching approaches, for example in Strand 3.2
- the need for a **manageable workload** particularly for some key people – e.g. regional coordinators, certain academics, part-time staff
- engaging other HEI and teaching staff who are not first-hand participants in CFOF – i.e. **spreading the value** of CFOF to a range of other colleagues and institutions who are not involved in the programme
- **moving beyond one-off** activities and experiences for pupils, particularly within Strands 1 and 4
- **targeting schools and participants** to further meet the target groups for CFOF as a whole, in particular 'widening the net' to engage schools who would not normally participate in such enrichment or outreach activity.

Additionality

All of the activities reported from CFOF are perceived to be **additional** and would not have been funded in the absence of the programme. Further added value comes from such aspects as **specialist equipment**, the teacher fellowships (which appear to cut across and become involved in **a number of the strands**), and the smaller **networks of practitioners** (e.g. in different HEIs) within CFOF who share resources and discuss practice. In relation to school participation, it will be important to build on this additionality by **encouraging a wider range of schools, in partnership with Aimhigher**, to participate further. This should include schools that are harder to engage and those that have not yet participated in CFOF.

Recommendations

The following areas will be important to consider in the extension phase of CFOF:

- continue to **embed new practices** in schools and HEIs where they have been developed, and **disseminate the resources and approaches** developed through CFOF:
  - **across all CFOF strands**, contributing further to programme integration
  - to the **rest of the chemistry community**, making clear where they can be used ‘off the shelf’ and/or be customised to fit particular student/course needs
- **‘widen the net’** to engage schools who would not normally participate in STEM enrichment or outreach activity
- invest in a **planned series** of activities rather than one-off experiences for young people (and their teachers), given the finding that more positive and long-term outcomes are realised when young people undertake a range of different chemistry activities
- **identify** those young people where CFOF is making a difference to their intentions to take chemistry further and focus attention on **consolidating and deepening** impacts for them (for example, with further targeted information and activity) (this will complement the wide net of broad impacts achieved so far)
- improve the **emphasis on and integration of careers information** in activities involving school pupils, including by developing partnerships with relevant employers and industries.

In addition, the extension phase of CFOF will require collaboration with other STEM organisations. The RSC will need to:

- plan for the **sustainability** of activities, e.g. through links with other regional STEM work
- work closely with the other HEFCE funded SIVS (strategically important and vulnerable subjects) programmes (Stimulating Physics, London Engineering Project, and More Maths Grads) to develop a **coherent STEM-based national programme** for roll out in July 2009.

Beyond the CFOF programme, staff from organisations planning for the national STEM-based programme should also consider the recommendations, and the challenges, highlighted in this executive summary. In particular, adequate **lead-in time** (e.g. for the recruitment of staff, and programme planning) prior to the delivery of the national STEM-based programme will be important. In addition, clear aims and objectives with measurable and realistic outcomes (not just outputs and activities) should be defined during the planning stages. The recent SIVs (Strategically Important and Vulnerable Subjects) programme report stresses the importance of providing 'measures of success at the outset … this would involve the specification of measurable but realistic outcomes, and the demonstration of a relationship between financial investment and identifiable returns' (Adams *et al*., 2008, p.28[1]). However, it is also important to note that openness and flexibility of aims allows participants to experiment, to find out what works and what doesn't work: this was a key strength of the CFOF programme.

[1] Adams, J., Mount, D.R., Smith, D.N. (2008). Strategically Important and Vulnerable Subjects: an interim evaluation of HEFCE's programme of support. Available [online]: http://www.hefce.ac.uk/Pubs/rdreports/2008/rd09_08/ 5th January 2009.

1. Introduction

1.1 Background to Chemistry for Our Future

This report presents the findings from the first full year (September 2007–October 2008) of the evaluation of Chemistry for Our Future (CFOF). The evaluation, which is being undertaken by the National Foundation for Educational Research (NFER) on behalf of the Royal Society of Chemistry (RSC), coincides with the second year of the pilot programme.

Chemistry for Our Future is a £3.6 million (funding total for this phase) pilot programme funded by the Higher Education Funding Council for England (HEFCE). The current phase[2] has been delivered over a two-year period by the RSC in partnership with universities, schools and other organisations. The key objectives of the programme are to:

- work with schools, colleges, industry and higher education institutions (HEIs) around the country promoting chemical sciences as a stimulating and profitable career route
- raise the aspirations of school pupils and widen and significantly increase participation in HE chemical science courses, particularly for under-represented groups[3], thereby sustaining chemistry as a strategic subject
- improve liaison and hence understanding across the key educational interfaces (primary, secondary, tertiary, HE and employment)
- investigate the best use of university chemistry laboratories and staff to deliver effective and efficient use of resources and provide good value for money
- review and develop HE teaching and learning (curriculum development) to ensure fitness for purpose with regard to educational outcomes for student participants and the skills and training needed by employers in both the chemical and non-chemical sectors
- explore opportunities for progression from vocational routes

[2] The changed landscape for Science, Technology, Engineering and Mathematics (STEM) over the course of the CFOF pilot means that CFOF currently stands as a two-year pilot, with a nine-month extension phase to July 2009, from where HEFCE will fund STEM work rather than chemistry-specific work.

[3] Under-represented groups include: people whose family have no experience of HE and young people in care; young people from neighbourhoods with lower than average HE participation; people from lower socio-economic groups; minority ethnic groups; people living in deprived geographical areas, including deprived rural and coastal areas; gifted and talented learners who have the potential to benefit from HE but who otherwise might not do so.

- provide a cohesive set of opportunities for teachers and students by working with the wide range of organisations and initiatives already involved in STEM promotion activities
- raise awareness of the key role chemists play in the development of a sustainable future for all and demonstrate that chemists provide many of the solutions for the global challenges faced in the 21st century.

CFOF has four key strands:

- Strand 1: University and Industry Outreach, including further roll-out of the widening participation project, Chemistry: The Next Generation (CTNG)
- Strand 2: Supporting Key Educational Interfaces – a Teacher Fellowship Scheme
- Strand 3: Higher Education Chemical Sciences Curriculum Development
- Strand 4: Widening Access to University Laboratories.

There are also two cross cutting themes:

- Theme 1: Careers
- Theme 2: Sharing Good Practice.

Further details on the aims and objectives of each of the four strands and two cross cutting themes are provided in Appendix A.

1.2 Aims and objectives of the evaluation

The overall aim of the NFER's evaluation is to evaluate the progress and impacts of the CFOF programme. Over the course of the year, we have explored: the progress to date of each of the four strands; the outcomes and impacts for school pupils, university students, teachers and HEI staff; what works well; the main challenges; additionality; next steps. Appendix B1 has further details on the research aims.

1.3 Methodology

The evaluation methodology recognises that this is a pilot programme, spanning two years, and that any change programme takes time. The evaluation has used a mixed-methods design including: desk-research;

meetings; interviews; focus groups; case studies with schools and universities; the development of standard evaluation tools for internal administration, such as survey questionnaires for pupils and teachers; and the tracking of a small sample of pupils (250) to establish ongoing and longer-term impacts. Through these methods, teachers, academics, pupils, undergraduates and strand managers have been consulted. Appendix B2 provides further details on the research methods.

1.4 Structure of the Report

This report presents the following sections:

Section 2	Programme management: an overview
Section 3	Strand 1: University and Industry Outreach
Section 4	Strand 2: Supporting Key Educational Interfaces – a Teacher Fellowship Scheme
Section 5	Strand 3.1: School-to-University Transition
Section 6	Strand 3.2: Chemistry for All
Section 7	Strand 3.3: Open-Learning Framework for Part-time Provision
Section 8	Strand 3.4: Mastering Bologna
Section 9	Strand 4: Widening Access to University Laboratories
Section 10	Outcomes and impacts: an overview of pupil questionnaire data
Section 11	Overarching findings, conclusions and recommendations

Each section considers, as appropriate, strand management, progress to date, outcomes and impacts, what works and lessons learnt, additionality, and next steps.

Appendix A	The Chemistry for our Future programme
Appendix B	About the research

2. Programme management: an overview

This section explores the effectiveness of the overall programme management of CFOF. It is based on interviews with RSC managers, partner coordinators, steering group members, HEI staff and school staff involved in CFOF. It includes some headline findings on the management of each strand. (Further details on the management of each of the four strands are provided in the individual strand sections in this report.)

2.1 Key findings

Four key messages emerge about the management of CFOF.

- Whilst **CFOF has been managed effectively** by the RSC staff and their partners, greater **human and financial resources** for management and coordination would ease the extensive workload that core staff experience.
- Managers acknowledge and have **learnt from early challenges** around recruitment, contractual arrangements, and the need for adequate start-up times. Current challenges remain around HEI **invoicing**.
- The way in which CFOF is managed has encouraged **effective sharing and dissemination of learning and good practice**, including what is **working well**, and, importantly, what is proving difficult or **challenging**. A **spirit of collaboration** and **openness** pervades the whole management of CFOF, including within strands, between strands, and from operational management level to Project Advisory and Steering Groups.
- Managers and partners at all levels recognise the **difficulty in evidencing impact within the limited time-scale of this pilot programme**. All acknowledge the opportunity of the extension phase to maximise evaluation and feedback and to evidence longer-term outcomes.

2.2 Introduction: programme management

The CFOF programme is overseen by a Steering Group which is informed by a Project Advisory Group. These groups were established to oversee the development and financial management of the programme. The Steering Group meets three times a year and includes representatives from HEFCE, the RSC, HE and industry in addition to the National STEM Director and a Secondary Science Consultant. The Project Advisory Group meets three times a year (before the Steering Group) and includes representatives from the RSC, the CFOF strand managers, industry, Aimhigher and Action on Access (HEFCE).

Each strand is managed or coordinated by an RSC CFOF staff member, in conjunction with partner coordinators acting either as a main university coordinator for the work (as in Strand 3.2 for example), or as a coordinator for the region (as in CTNG in Strand 1 for example, where the RSC staff member coordinates the work of the regional coordinators based in HEIs).

2.3 How well is the CFOF programme being managed?

2.3.1 How well is the programme managed by the RSC?

All of the managers (operational and advisory/steering level) and partners we interviewed feel that the CFOF programme is being **managed effectively** by the RSC. Many acknowledge that CFOF is a large and ambitious programme. With this in mind, some interviewees suggest that, ideally, **greater resources for management and coordination would be beneficial** – for example through increased staffing at operational management level. This would also alleviate some of the extensive workload and 'over-stretching' of staff reported. Such views were expressed at operational and advisory/steering level.

2.3.2 What management, monitoring and evaluation information is provided to the Steering Committee and Project Advisory Group?

We consulted members of the Steering and Project Advisory Groups about the **level of feedback** they receive on CFOF. They report receiving:

- information about the progress of the strands
- quantitative information about the level of activity in each strand
- qualitative feedback on what is working well and less well in each strand.

All of those consulted feel that the information they receive has been **sufficient** to make decisions and judgements about the progress of CFOF. However, whilst they note ample feedback on shorter term and 'softer' outcomes, such as changed thinking and attitudes (for example, students' more positive attitudes towards chemistry careers), **two key areas where more information is required** are:

- detail on **what makes the difference** (i.e. what contributes to positive outcomes)
- evidence of longer term outcomes.

However, all of the managers we interviewed note the **challenge of evidencing longer term outcomes** within the timescale of this pilot programme (see challenges below).

2.3.3 How well are the strands being managed?

In general, interviewees feel the strands are being managed well. The experience of the original three pilot regions in particular has helped the set up, management and delivery of CTNG in three new regions in Strand 1.

In the interim report, we noted the **late start** of the Open Learning Framework (Strand 3.3) and the Teacher Fellowship Scheme (Strand 2). Likewise, in Strand 3.2, some of the projects were reported to be 'slower off the ground' than others. Whilst many of these issues are no longer a concern, compared with other activities, the **management of Strand 3.3 is highlighted as less effective** than other strands. Staff moves and a re-configuration of activities contributed to this.

Further details on the management of each strand are given in the relevant strand sections of this report.

2.3.4 How well are managers and partner coordinators supported?

Strand managers/coordinators themselves feel **well supported from within the RSC**. Partner coordinators are also felt to be supported well. The key findings are:

- there is a **spirit of collaboration** and **openness** amongst CFOF managing partners, including between CFOF Strand managers and their lead university or other partners
- there is good **two-way communication** between the RSC and partner coordinators on each strand

- the HEI academics are very enthusiastic partners
- there is a 'good team spirit' is reported amongst Strand 1 regional coordinators.

2.3.5 To what extent is CFOF an integrated programme?

CFOF is felt to be an **integrated programme**. There were early perceptions of 'fragmentation', but most manager interviewees now feel CFOF is 'knitted together' well. The connections are **not necessarily linear**, but are felt to provide a **network** of links. For example, the programme offers activities linking the school curriculum through transitions to university study; it addresses practical chemistry, and university orientation more broadly; it links teaching staff with HEI staff; and it includes overarching themes such as careers and sharing practice.

2.3.6 To what extent does CFOF have clear aims and objectives?

Programme and project managers feel that a key strength of the CFOF programme is its overall openness and flexibility, which allows participants to experiment, to find out what works and what doesn't work. However, it is also reported that having clearer aims and objectives with measurable and realistic outcomes defined during the planning stages of the programme could have been beneficial to assessing progress and success. The recent SIVs (Strategically Important and Vulnerable Subjects) programme report stresses the importance of providing 'measures of success at the outset … this would involve the specification of measurable but realistic outcomes, and the demonstration of a relationship between financial investment and identifiable returns' (Adams *et al*., 2008, p.28[4]).

2.4 What management challenges are there?

The interim report noted a small number challenges in the early programme management of CFOF:

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[4] Adams, J., Mount, D.R., Smith, D.N. (2008). Strategically Important and Vulnerable Subjects: an interim evaluation of HEFCE's programme of support. Available [online]: http://www.hefce.ac.uk/Pubs/rdreports/2008/rd09_08/ 5th January 2009.

- **insufficient start-up time** being allocated in the HEFCE bid to setting up the programme and recruiting RSC programme management staff
- a mismatch between the capacity of the programme management team and the workload which was resolved through the appointment of an additional member of staff
- the **time-consuming contracting process** which, in some cases, led to a delay in appointing or allocating staff to projects which resulted in some projects starting late.

Whilst these early challenges have been acknowledged and learnt from, operational and steering/advisory level managers report two continuing challenging areas:

- coordinating the transfer of funds from RSC to universities, including a time lag in universities **invoicing systems**
- the **challenge of demonstrating impact within a short timescale**: 'the two-year time window is a very short one … two years isn't a lot of time to get a big project up and running, and also to deliver the deliverables and to evaluate the outcomes'.

All of the managers we interviewed approved of the **spirit of openness** within CFOF to '**testing out**' a whole range of activities, and learning from those that do, and don't, work. However, with hindsight, some interviewees suggest that CFOF developers might have focused their efforts better on a more limited range of activities, given the finite resources of the pilot.

2.5 What sharing and dissemination activities take place?

Cross-Cutting Theme B emphasises the sharing of learning and good practice, both within and across strands. Activities include:

- the first CFOF national conference held at Aston Business School in July 2007, with over 100 attendees from national organisations, universities and schools
- a curriculum development symposium for Strand 3.1 in July 2007 which attracted approximately 25 attendees
- Strand 1 regional coordinator meetings, held quarterly
- a one day meeting held at the end of November 2007 for project partners in Strand 3 and Strand 2 teacher fellows
- a meeting of the CFOF and Institute of Physics teacher fellows in March 2008

- the second CFOF national conference held in Aston in July 2008
- a curriculum development symposium for Strand 3.1 in July 2008

Participants find these opportunities to learn from each other and to network **very beneficial**. The annual conference is not only an **opportunity to share** practice, but also to **generate resource material**. More regular meetings to share practice between the Strand 1 regional coordinators have been requested, although this may not be practical due to the part-time nature of their role.

Information about the activities and achievements of the whole CFOF programme is also included within a CFOF newsletter which comes out twice a year. The newsletter is sent to a mailing list of around 250 people which includes project partners, Aimhigher staff, representatives from industry and representatives from other science professional bodies and providers of outreach and enrichment activities. There is also a CFOF flier and a significant amount of detailed information about the programme, its four strands and its cross-cutting themes is included on the CFOF website (www.rsc.org/cfof). Additionally, a number of resource packs focused on sessions that can be delivered for 5–18 year olds have been developed for a range of topics (for example, of Strand 1 work).

2.6 What are the next steps for the management of CFOF?

The extension phase of CFOF is seen by managers as an opportunity to:

- evidence longer-term outcomes
- gauge which activities work well, and which are not worth further investment
- maximise evaluation and feedback by improving evaluation and monitoring data capabilities – for example, to track specific cohorts of students
- sustain and embed activity
- consider the role of chemistry within a wider STEM programme
- integrate careers activities further within CFOF, including achieving outcomes around careers awareness
- further emphasise transferable skills and the wide applicability of those skills beyond chemistry careers.

The need for **ongoing management support** was raised: '… it's never going to be fixed. If we take our foot off the pedal, it'll slip back … these sorts of things need constant maintenance'.

3. Strand 1: University and Industry Outreach

This chapter presents the first year evaluation findings for Strand 1, University and Industry Outreach to Schools. Strand 1 comprises of Chemistry: the Next Generation (CTNG), Future Blogs (e-mentoring) and Spectroscopy in a Suitcase. The latter aspects of the strand have been/will be evaluated separately by the NFER, and hence this chapter focuses specifically on the progress and outcomes of CTNG. The CTNG project provides university and industry outreach to schools in order to promote the engagement and excitement in the chemical sciences and demonstrate the career opportunities available to students underrepresented in higher education.

The chapter includes detailed information of the outcomes of the strand, drawing on perceptual and statistical data. Findings are based on consultations with the national strand manager, regional coordinators, members of the CTNG National Management Committee, and school teachers and pupils.

3.1 Key findings

- The **initial target for 2006-08 has been exceeded**: 47,000 pupils from around 800 schools have been involved in CTNG during this period, exceeding the original target of 30,000 pupils. Within each region, activities are being delivered in collaboration with partners and are successfully attended and received by teachers and pupils. Seventy per cent of pupils engaged are from Aimhigher cohorts.
- **CTNG activities are relevant, practical and hands-on,** which are key positive elements for pupils. In addition, teachers are able to become involved and take ideas back to the classroom. Collaboratively delivered activities are also reported to be particularly successful in terms of providing pupils with exposure to a range of organisations and facets of chemistry.
- **Key messages for the development of the strand** emerge around the need to: explore and remove barriers to schools' and FE colleges' participation; explore the potential for development of series of activities (as opposed to one-off events); improve the emphasis on and integration of careers information in activities, and; develop partnerships with industrial and employer partners in order to promote the chemical sciences and career opportunities.
- **CTNG has strong positive outcomes for pupils**, particularly in terms of developing their awareness of HE; influencing their future intentions towards chemistry, and; improving their understanding of the relevance

and usefulness of chemistry. Where the impacts are strongest, the strand also has the capacity to influence pupils' future intentions and increase their intentions to further participate in chemistry thus impacting on widening participation.

- CTNG activities result in positive **impacts on the teachers** involved, particularly in terms of enhancing access to resources and materials, improving **links with HEIs/industry/other schools**, and raising the profile of chemistry in the school. Where the impacts are strongest on teachers involved there is also the capacity to impact positively on chemistry teaching, including providing teachers with ideas, knowledge and awareness to help support and enrich their chemistry teaching.
- Wider impacts of the project have also been evidenced in the regions, including: impacts on Higher Education Institutions (HEIs) e.g. in terms of changing academics' opinions on engaging in outreach; **the nature and prevalence of university and industry outreach**; and greater awareness and collaboration between schools and HEIs.

3.2 Introduction to Strand 1

Strand 1, University and Industry Outreach to Schools comprises of Chemistry: the Next Generation (CTNG), Future Blogs (e-mentoring) and Spectroscopy in a Suitcase. The strand provides a range of one-off, one day activities as well as some residential activities provided by universities and industrial partners to school and college pupils in order to promote engagement and excitement in the chemical sciences and demonstrate the career opportunities available to students underrepresented in higher education.

The aims of Strand 1 are to:

- provide a diverse range of chemistry outreach activities in university laboratories and industry
- provide chemistry outreach activities for students at schools and colleges and/or at regional events
- develop 10-15 outreach materials for national dissemination
- develop regional subsets of the chemistry outreach website
- provide Spectroscopy in a Suitcase in three regions
- develop the e-mentoring infrastructure.

The evaluation methodology for this strand included: case studies with five schools (including interviews with 20 pupils and five teachers); survey administration to 110 school pupils, and follow-up 'tracking' surveys with 46 of these pupils some six to nine months later; follow-up telephone interviews with four teachers in the five case study schools; a focus group and the administration of e-mail questionnaire proformas with six regional coordinators; telephone interviews with the CTNG national manager; and consultations with the coordinators of Future Blogs and Spectroscopy in a Suitcase.

3.3 Strand management

This section presents the findings from two interviews with the CTNG National Manager and proforma returns from the regional coordinators in relation to how the strand is managed, the effectiveness of strand management; management challenges; and the effectiveness of the internal evaluation procedures for the strand.

How the strand is managed

CTNG is being run in six regions: East Midlands, North West, London, Yorkshire and the Humber, North East and South East. It is managed nationally by the RSC and by regional coordinators based in host universities in each of the six regions. Regional coordinators organise and manage the activities delivered in their region in collaboration with key partners and stakeholders. The management structures also comprise:

- A National Management Committee which convenes quarterly and which is the strategic decision making body for the project, overseeing and ratifying all activity across all regions. Representation comprises of the CTNG national manager and key stakeholders within the STEM arena.
- Regional Steering Groups which are convened quarterly and which are responsible for making decisions in relation to the range and scope of activities delivered in each region. Representation includes key STEM stakeholders in the region (e.g. Aimhigher, STEMNET, the Science Learning Centre, the RDA, academia, industry and Cogent or SEMTA Sector Skills Councils), as well as the national manager of CTNG, the respective regional coordinator and a representative from the operational group. Members of the Regional Steering Groups are generally already involved in coordinating, funding or managing STEM initiatives and have an understanding as to regional needs and gaps. They are felt to be well placed to identify what additional chemistry based activities are needed in each region. The groups decide what, out of the menu of possibilities that the operational group offers, is relevant for the region.

- **Operational Groups** in each region are convened quarterly and involve the meeting of project partners responsible for delivering outreach activities (e.g. universities and industrial representatives) to share ideas, plan activity, share good practice and decide what is possible within the region.

The CTNG national manager supports and manages the regional coordinators on a day-to-day basis, including guiding the planning of activities and ensuring connections are made with other agencies with a STEM agenda. The national manager monitors the overall budget for the project, which is allocated to each region.

Effectiveness of management

Although the management of the project is deemed to be **demanding** for the national manager, **sufficient support is felt to be in place**. The strand is felt to be being **effectively managed** in terms of the support received by regional coordinators and opportunity for **team work, collaboration and sharing good practice** across the regions (despite geographical distances). There is also a growing ethos amongst CTNG partners and university staff of an **appreciation of the collective gains** and impacts for chemistry generally from the CTNG project. Considerable effort has gone into promoting this ethos by the CTNG national manager and regional coordinators, ensuring understanding of the principles and purposes of widening participation, particularly of the need to remove the barriers preventing some more disadvantaged groups of pupils from participation in higher education. **University academics** are also reported to have expended efforts to promote the benefits of CTNG to admissions tutors and faculty heads/deans. In particular, they are working to change opinions of CTNG type activities from being perceived purely as recruitment exercises, to being seen as beneficial to the whole chemistry community (see section 3.5.5 for examples of impacts on HEIs).

Other management attention has been required in terms of ensuring **clarity around the role of the regional coordinators**, who in some instances have been used for additional tasks in the host universities which are outside of their CTNG remit.

Within Strand 1, **exchange of good practice across the regions** is felt to be effective. The regional coordinators meet face to face with the CTNG national manager bi-monthly and effective working relationships are facilitated amongst the regional coordinators themselves by good lines of communication and periodic face-to-face meetings. As highlighted in chapter 2 on programme management, across the whole CFOF programme, there may be scope for further integration and exchange of good practice and learning around the delivery of the various strands. Although the national conference in July provides a forum for this sharing, to attain greater integration there may be a need for more management and coordinator resource.

The regional coordinators are praised for their positioning as points of contact for chemistry outreach in their respective regions. The CTNG national manager and regional coordinators feel that the role is helping the CTNG project to become recognised amongst schools and other partners as a high quality brand of chemistry enrichment activities, a key factor that may help to sustain the project beyond 2009. The strand has achieved **effective collaborative working** between project partners and there is trust and willingness for **joint working between the universities** involved.

Management challenges

There are still issues in terms of **membership and participation on steering groups** from the key STEM stakeholders in the regions (e.g. STEMNET, RDAs, Cogent etc.), who tend to be extremely busy, despite their interest in being involved in the project. This has impinged, to some extent, on the capacity of the regions to **ensure coordination with other STEM initiatives**, sufficient coverage of any gaps in provision and exposure of the CTNG project. It is anticipated that the national emphasis on improving the coordination and coherence of STEM initiatives (e.g. the DCSF STEM programme, including the STEM directories) will aid this, though the CTNG national manager and regional coordinators are also exploring other ways of liaising with such representatives (e.g. virtual meetings, email contributions, delegated membership etc.).

Internal evaluation

All CTNG activities collect pupil and teacher evaluation via feedback forms completed after the events. This evaluation data is used to inform regional planning (e.g. regarding the continuation or modification of activities), and is also collated nationally to provide some indications as to the impacts of the project (e.g. proportions of pupils intending to participate further in chemistry following experiences of the CTNG activities). However, the need for more sophisticated analysis and evaluation of pupil feedback data is identified, for instance, being able to better assess the extent of impacts from activities and the degree of attribution to the CTNG project. Plans are in place to improve the internal evaluation during the 08-09 extension year, including a revised evaluation strategy to evaluate a smaller proportion of activities in greater depth.

3.4 Progress to date

The progress of CTNG in relation to outputs and spend

The total funding allocated to CTNG (including staff costs) to date in September 2008 is £1,217,000. The entire sum of this figure will have been spent by the end of November 2008 (when outstanding invoices have been recovered). In relation to the targets that were originally set, Strand 1 has progressed well. The initial target set for 2006-08 to work with 30,000 pupils has been exceeded, as a total of 47,000 pupils from around 800 schools have been involved in the strand during this period.

The strand has also achieved its target to work with 70 per cent of pupils from an Aimhigher cohort as part of its aims to widen participation i.e. those based within communities that are under-represented in higher education and pupils whose parents/carers have not themselves studied within higher education.

In relation to resources, the target was for 10–15 outreach resources to be developed over the course of the 06-08 funding. In January 2008, seven CTNG resource packs had been created focused on sessions for 5-18 year olds. The target for the 06-08 has thus not quite been reached, although more resources are planned for the 08-09 extension year in order to exceed this aim.

Activities delivered as part of CTNG

The majority of activities delivered to young people through CTNG are one-off activities taking up half of or a full day. In most cases, activities are based at universities, with a smaller proportion of activities being school-based for example, chemistry ‘road shows’, where kit is taken out to schools (particularly to meet the needs of rural areas). Activities are most often delivered by university academic staff and postgraduates, but are sometimes also supported and delivered by chemistry employers and industrial representatives, and organisations and charities delivering STEM and other outreach (e.g. STEMPOINT, Aimhigher, SciTec, Salters etc.). The events mainly involve practical, ‘hands-on’ activities, though some large-scale, stage events are also being delivered for large numbers of pupils as well as a smaller number of residential interventions.

Across the six regions the following types of activities have been run this year (in basic order of frequency):

- hands on sessions (approximately 119 activities)
- visits to universities/university taster sessions (approximately 52 activities)
- visits to university laboratory facilities (approximately 50 activities)
- lectures and demonstrations (approximately 48 activities)
- fairs, promotion events, visits to industry, summer schools, teacher events and museum visits (over 20 activities).

Most of the activities that are being delivered are solely funded through CTNG funds with support ‘in kind’ – primarily staff and employee time – being provided by higher education and industry. In addition, a few activities and events are co-funded/match funded by Aimhigher and other agencies, for example the RDAs. The regional coordinators have worked to secure this additional funding.

Young people involved

Recruitment of participants to the CTNG activities and events is largely targeted at Aimhigher schools (i.e. 70 per cent) in collaboration with Aimhigher area leads and school based coordinators. There is particular targeting of those Aimhigher schools that have not previously been involved in STEM outreach activity. There is flexibility in the remaining 30 per cent of young people engaged by the CTNG programme. Schools that have previously engaged with the project or other science outreach activity (e.g. through university intelligence) are often targeted. In terms of the selection of pupils, this is left up to Aimhigher coordinators or teachers with responsibility for widening participation in individual schools, though is often decided in discussion with regional coordinators regarding the nature of events and types of pupils who may benefit. Some activities involve whole year groups of pupils where there are much looser selection criteria.

Other criteria informing decisions about activities to be offered include the need to provide activities for a range of year groups and geographical areas.

Pupils participating in the programme have ranged from year 6 in primary schools to year 13 in secondary schools, although there is a particular emphasis on providing interventions for key stage 3 age pupils (i.e. Years 7–9), who the national manager feels is the group that offers the greatest scope for positive and longer term impact.

Schools involved

Schools are informed of up-coming activities and events via email or letter, though where events are under-subscribed, individual schools may be directly approached. Databases of participating schools are kept for each activity/event and these schools are informed of future activities.

A mixture of high and under performing schools attend the CTNG events, although **engaging lower performing schools is felt to be more challenging** and limits are set on the numbers of high achieving schools eligible to participate (in line with the 70:30 per cent ratio discussed above). It is recognised by regional coordinators that participating schools often possess the following key features: stable staff; supportive management structures; established relationship of trust with regional coordinator; pro-activity regarding engaging in enrichment and enhancement activities; science specialist status; an active science department; and enthusiastic teachers. In addition, issues relating to teacher cover and behaviour management are more likely to be associated with lower performing schools and thus these schools face more barriers and challenges to utilising the CTNG activities. It is a priority for 2008-09 to continue to explore and remove the barriers faced by such schools to further widen participation.

Other Strand 1 activities

Future Blogs was developed in collaboration with The Brightside Trust, based on the Bright Journals e-mentoring programme. The aim was to provide an innovative e-mentoring service that would support school students from years 9–13 with an interest in science, particularly those from a widening participation background. The role of the mentor was to develop a supportive relationship with the mentee and to provide advice and information to help the mentee in their educational and career choices. As well as e-mentoring, the scheme also provided an extensive website with information relevant to students studying science or chemistry, or considering science or chemistry related careers. The Future Blogs scheme was launched in April 2007 and ran until the end of the 2008 academic year.

The programme was administered at a local level by 10 voluntary academic coordinators (from different universities) with support from the RSC/Brightside Trust. RSC members were also invited to become ‘industrial mentors’. From each of the universities, academics, postgraduates and graduates were recruited as mentors. Overall, 276 mentors were recruited from universities. An additional 45 ‘industrial mentors’ were recruited from the RSC. The 31 schools that participated in Future Blogs recruited 301 student mentees from years 9 to 13. The frequency with which students posted to their mentee was variable with around half the students posting infrequently (0–1 postings) and about a third of students posting to their mentors more than five times.

The NFER completed an evaluation of the Future Blogs scheme between February 2008 and July 2008. This evaluation aimed to develop a greater understanding of the views of the students and teachers who had participated in the scheme and to assess their opinions on the relative success of the scheme. Some key findings from this evaluation are outlined below:

1. All of the students who had made contact with their mentors were positive about the responses they received. Many students also found the articles and other resources on the website useful but there was concern from some regarding how relevant this information was to their studies.

2. Students mainly accessed Future Blogs from home. On the whole students reported that that they had received very little additional support from their teachers and most were pleased that it was something they could do by themselves.
3. Future Blogs has positively impacted on students' understanding of the relevance and usefulness of chemistry.
4. Some teachers suggested that they were not clear what their role should have been to support students to make better use of Future Blogs.
5. Future Blogs was not incorporated into either chemistry or career lessons.
6. Teachers were generally positive about the content and structure of the Future Blogs website.

In July 2008, a decision was made by the RSC CFOF Steering Committee and Project Advisory Group not to continue further with the Future Blogs scheme.

Spectroscopy in a Suitcase also forms part of Strand 1. The activities are managed overall by a coordinator at the RSC, with four coordinators managing the local activities. Four CTNG regions are involved, with two delivery models:

- Model A – in three regions (East Midlands, London and South East) – where postgraduate students are trained to use the equipment, and then to deliver workshops in schools (each region has a different combination of equipment available in their '*suitcase*')
- Model B – in one region (North East) – where school teachers are trained to use the equipment (six sets are available) and they then deliver workshops to students in their own schools.

The aims are to provide hands-on experiences of spectroscopy for students, and teachers, and to contextualise the use and relevance of spectroscopy in the real world (e.g. forensics, product quality control).

Spectroscopy in a Suitcase was launched in July 2007. The funding allocated is £127,000. To date, 'Suitcase' equipment has been purchased for four regions, and training activities have taken place in those regions (using both Models A and B – i.e. postgraduate delivered and teacher delivered respectively). A number of workshops have been run, but it is early days. The pilot-phase aim for 10 'workshops' to be run in the East Midlands and North East regions and 10 in the London and South East regions combined has been achieved. Activities for the academic year 2008–09 are now being booked and delivered. Other activities complementing Spectroscopy in a Suitcase include the website 'SpectraSchool' www.spectraschool.org, the second phase of which will be re-launched with teachers at the Association for Science Education event in January 2009, and the production of a DVD of modern instrumental techniques. This DVD has been distributed to all schools and colleges with a sixth form in England and the digital content of the DVD is now available through the RSC site and YouTube. Other activity around Spectroscopy in a Suitcase also includes the sharing of practice within and across regions by those involved in delivering the training to use the equipment.

Spectroscopy in a Suitcase will be evaluated separately by the NFER through a case study approach in the academic year 2008–2009.

Strand 1 activities in the case study schools

The five Strand 1 case study schools that participated in the NFER CFOF evaluation have been involved in the following CTNG activities (reported by the teachers and the pupils):

- visits to universities to participate in lectures, workshops, demonstrations and competitions relating to chemistry, including some hands-on activity, e.g. a Forensic Science Day, Spectroscopy Day, Murder in the Lab, Analytical Chemistry, Chemistry at Work (all five schools, schools A, B, C, D and E)
- activities in museums, e.g. the V&A in London, and Catalyst on Merseyside (three schools, schools B, C and D)
- participation in other science/cross-science activities, e.g. an Allied Healthcare day (one school, school B)
- inter-school activities, e.g. the CREST award (one school, school D)
- chemistry summer camps (two schools, school B and school C)
- on-line mentoring/tutoring, e.g. Future Blogs (one school, school A).

Table 3.1 below shows the range of Strand 1 activities which have been undertaken in each of the case study schools (as reported by teachers). A * indicates the activities that the particular pupil interviewees also talk about. Note that interviewees feel that the activities that they have participated in are mainly chemistry focused, rather than 'careers' focused. Also note that pupils do not necessarily know the names of the events/activities they have participated in, and do not necessarily recall all such events/activities.

Table 3.1: Strand 1 activities in the NFER case study schools

School A • Visits to universities to participate in lectures, workshops and demonstrations relating to chemistry (e.g. Forensic Science Day, and Spectroscopy Day, university visit day*) • On-line mentoring/tutoring (e.g. Future Blogs*)	**School B** • Visits to universities to participate in lectures, workshops and demonstrations relating to chemistry (e.g. Spectroscopy Day, Murder in the Lab, Chemistry of Sport lecture, Chemistry at Work, workshops on colour chemistry*, organic molecules, polymer chemistry*) • Activities in museums (e.g. art and chemistry event) • Participation in other science/cross-science activities (e.g. an Allied Healthcare day*) • Chemistry summer camps (Salters Chemistry Camp)
School C • Visits to universities to participate in lectures, workshops and demonstrations relating to chemistry (e.g. Spectroscopy Day*) • Activities in museums (e.g. V&A) • Chemistry summer camps*	**School D** • Visits to universities to participate in lectures, workshops and demonstrations relating to chemistry * • Activities in museums (e.g. Catalyst*) • Inter-school activities (e.g. the CREST award*)
School E • Visits to universities to participate in lectures, workshops demonstrations and competitions relating to chemistry (e.g. Spectroscopy Day, analytical chemistry) • Chemistry at Work*	

3.5 Outcomes and impacts

This section examines the impacts of CTNG on those involved.

3.5.1 Outcomes and impacts for pupils

This section examines the impacts of CTNG on the school pupils involved. A sample of teachers and pupils who have experienced CTNG have been consulted. Data are drawn from initial survey questionnaires[5] with 110 pupils and follow-up questionnaires some six to nine months later with 46 pupils; semi-structured interviews with 20 pupils (from year groups 10-13); five teacher interviews and four teacher follow-up interviews; proforma returns from the six regional coordinators, and; telephone interviews with the CTNG national manager.

This section will:

- describe the pupil sample in terms of their attitudes to chemistry, chemistry further study and higher education
- consider, thematically, the types and extent of outcomes for pupils from participating in this strand (including knowledge, skills and attainment in chemistry; awareness and understanding of HE, chemistry in HE and chemistry careers; attitudes and perceptions of chemistry; and future intentions and participation in chemistry). Each theme explores the initial questionnaire data, pupil views, teacher views, and other views (e.g. regional coordinators' views, and the CTNG national manager's views).

Section 3.5.2 then goes on to explore some of the findings from the CTNG internal database of feedback forms provided by the RSC to the NFER evaluators. Section 3.5.3 then explores the impacts of chemistry interventions over time, comparing pupils' views towards chemistry at two time points (i.e. autumn term 2007 and summer term 2008).

Pupils' attitudes to chemistry

The initial survey questionnaire asked pupils to rate a series of statements on a 1 to 5 scale (with 1 representing a negative response and 5 a positive response) in order to gauge their overall attitudes to chemistry. Their responses are presented in Table 3.2 in a rank order with the most positive responses listed first.

[5] As a starting point to the evaluation an initial survey was carried out during the autumn term 2007 with pupils who were known to have already experienced some CTNG activity. It is important to stress, therefore, that the initial survey data does not provide a 'baseline' picture of pupils' views. With a subsample of these pupils a follow-up survey was then conducted in the summer term 2008.

Table 3.2: Attitudes to chemistry, chemistry further study and HE: Strand 1 pupil survey sample

Statement	Mean rating
I do not intend/do intend to go to university	4.6
Chemistry is not useful/is useful for jobs/careers	4.2
I don't know/do know a lot about higher education	3.8
Do not enjoy/enjoy chemistry	3.7
I do not feel/do feel prepared for higher education	3.7
There aren't/are interesting/exciting chemistry careers	3.6
I am not doing/am doing well in chemistry	3.5
I do not like/do like the way chemistry is taught	3.5
Chemistry is not useful/useful for everyday life	3.4
I am not/am aware of a range of chemistry careers	3.4
I don't know/do know a lot about what chemists do	3.3
I do not/do intend to take chemistry further as a subject	2.8
Chemistry is hard/easy	2.7
I do not intend/do intend to take chemistry for a job/career	2.5
	N=110

Source: NFER pupil survey, 2007-08
A total of 110 respondents gave a valid response to at least one of these items

Table 3.2 shows that the sample of pupils consulted already have strong intentions to go to university (mean rating of 4.6). The pupils feel that they know quite a lot about university and higher education, and feel well prepared for this phase of their education (rating these items on average as 3.8 and 3.7 respectively).

The respondents also appear to hold fairly positive attitudes towards chemistry, including enjoyment (mean rating 3.7), and particularly positive perceptions of its relevance and usefulness for jobs and careers (mean rating 4.2) and, to a lesser extent, the usefulness of chemistry for everyday life (mean rating 3.4). The pupils seem slightly less confident about their knowledge of chemistry careers and what chemists do (mean ratings of 3.4 and 3.3) though they are reasonably positive that there are interesting and exciting chemistry careers (mean ratings of 3.6).

Pupils also report that they quite like the way chemistry is taught in school (mean rating 3.5) and tend to feel they are doing quite well in chemistry (mean rating 3.5) (indeed the majority of the sample could be considered as fairly high achievers). The respondents are more ambivalent and negative in their views about how difficult they perceive chemistry to be, with most pupils giving a response of 3 or less, indicating that they find chemistry hard, rather than easy, resulting in a mean rating of 2.7.

Pupils' views are less positive when asked whether they intend to take chemistry further as a subject, represented by an average rating of 2.8, and fewer still intend to pursue a career in chemistry (mean rating 2.5).

Overall, the pupils in the Strand 1 pupil survey have reasonably positive attitudes towards chemistry. However, this positivity does not appear to have translated into an affirmative attitude towards taking chemistry for further study or a career. In terms of their initial attitudes, the majority of pupils indicated that they were not thinking of pursuing this pathway.

Typology of the impacts on pupils

The section will now examine the impacts of participation in the CTNG programme on pupils. Overall, the strongest positive impacts of this strand appear to have been on pupils' awareness of higher education, future intentions (e.g. study and career plans) and their understanding of the relevance and usefulness of chemistry. The types of impacts on pupils will be discussed in the following themes:

- Knowledge, skills and attainment in chemistry
- Awareness and understanding of HE, chemistry in HE and chemistry careers
- Attitudes and perceptions of chemistry
- Future intentions and participation in chemistry.

The impacts of the programme on pupils are then presented and discussed together towards the end of this chapter in section 3.6, examining the additionality of the CTNG programme.

Knowledge, skills and attainment in chemistry

The initial questionnaire asked pupils to rate on a 1 to 5 scale (with 1 being 'not at all' and 5 being 'a great deal') the extent to which their experiences of chemistry interventions, such as CTNG[6] have made a difference to their knowledge and skills and how well they are doing in chemistry. Their responses are presented in Table 3.3.

Table 3.3: Impact ratings: Strand 1 pupil survey sample

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Chemistry knowledge and skills	2	15	32	38	8	3.4
How well you're doing in chemistry in school	8	13	36	32	8	3.2
N=110						

Source: NFER pupil survey, 2007-08
A total of 110 respondents gave a valid response to at least one of these items

Pupils give an average response of 3.4 and 3.2 for each of these items on the 1 to 5 rating scale. Forty-six per cent of pupils rate the impact on their chemistry knowledge and skills with a 4 or 5, indicating that the experience has made ‘quite a lot’ or ‘a great deal’ of difference. Forty per cent of pupils rate that their experiences of CTNG have made a difference to how well they are doing in chemistry in school. Although CTNG is having a positive impact on some pupils’ chemistry knowledge, skills and attainment, this outcome is not the strongest of this strand.

Pupil views

Pupils interviewed were asked to discuss the impacts of CTNG activities on their knowledge, skills and attainment in chemistry.

Chemistry knowledge and skills – the majority of pupils (16 out of 20) report that they have benefited in this way to at least some degree. Pupils point out that they have developed their chemistry knowledge and skills particularly when the activities involve hands-on and practical elements. Others attribute their learning to the more advanced chemistry dealt with during the CTNG activity in comparison to school, the opportunity to revise previous learning

[6] The survey questionnaire asked pupils to comment on any chemistry activities and events they may have experienced, not necessarily only CTNG activities. It was recognised that pupils may find it difficult to distinguish CTNG activities from others they may have experienced and that it is important to be aware of other chemistry interventions pupils have been exposed to. Teachers were able to verify that the pupils completing the questionnaire had experienced at least one CTNG activity.

and learn chemistry by seeing it in action. Some pupils feel they have gained a general, broader awareness of what chemistry entails or learnt about chemistry careers and chemistry in the real world, as this pupil describes: '*Yes, they* [CTNG activities] *help me learn more about what goes on in chemistry and what it is all about*'.

How well they are doing in chemistry (i.e. achievement/attainment) – most of the pupils we interviewed are sceptical about whether the activities make a difference in this respect. However, some feel the experience aids their understanding of chemistry and motivation towards learning chemistry, as this pupil explains: '*I have applied some of the trips I've been on to my lessons'*. Several others went further to suggest that the knowledge and skills gained has helped them towards their grades in exams.

Teacher and coordinator views

The teachers too feel that the impacts on their pupils from Strand 1 activities are new chemistry knowledge and skills, **making connections between their curriculum chemistry and chemistry in the wider world**. Teachers suggest that the chemistry activities stand out in the pupils' memories and they refer back to them when similar topics and theory are covered back in school. Teachers agree with pupils and suggest that impacts on knowledge and understanding are most prevalent when the activities provide opportunities for pupil involvement and participation and are pitched at an appropriate level.

Regional coordinators are more divided in their perceptions of such impacts; half suggest that according to pupil and teacher feedback, pupils' chemistry knowledge and skills are positively impacted by the CTNG activities, whereas half indicate only moderate impacts in this regard.

Awareness and understanding of HE, chemistry in HE and chemistry careers

The initial questionnaire asked pupils to rate the extent to which their experiences of chemistry interventions, such as CTNG, have made a difference to their awareness and understanding of higher education generally, chemistry in higher education and chemistry careers. Their responses are presented in Table 3.4.

Table 3.4: Impact ratings: Strand 1 pupil survey sample

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Awareness of higher education generally (e.g. what university is like)	5	7	26	38	21	3.7
Awareness of chemistry careers/what chemists do	7	21	31	29	8	3.1
Awareness of chemistry courses in higher education	9	22	35	25	6	3.0
N=110						

Source: NFER pupil survey, 2007-08
A total of 106 respondents gave a valid response to at least one of these items

The table above shows that pupils rate highly impacts from the CTNG activities they have experienced on their awareness and understanding of higher education generally (mean rating 3.7). Fifty-nine per cent of pupils rate strong impacts of this nature, thus this constitutes the most notable single impact on pupils involved in Strand 1. Pupils are less likely to report such strong impacts of the strand on their awareness of chemistry careers (mean rating of 3.1) and chemistry courses in higher education (mean rating 3.0). Thirty-seven per cent and 31 per cent of pupils rate these items with a 4 or 5 respectively, indicating strong impacts of this type for around a third of pupils.

Pupil views

Qualitative discussions with pupils during interviews reveal further detail on impacts on young people's understanding and awareness as a result of being involved in CTNG activities.

Understanding of higher education generally – nearly three quarters of the interview sample (14 out of 20) feel their involvement in CTNG activities has raised their awareness of higher education, as this one pupil points out: '*Yes I've seen what it's like at university and how it works there. It's like wow because this is what university life is like, it was good*'. The pupils stress the importance of physically visiting a university as part of these activities in helping them to get a feel for what it's like. Also important was the opportunity for contact with people from universities, such as lecturers and students.

Understanding of chemistry careers/what chemists do – pupils are divided as to the prevalence of this impact: half feel they learned a lot about what chemists do from their experiences of CTNG and half feel that they remain unsure about what chemistry careers might involve. The former group of pupils feel they have a better understanding of the variety of careers involving chemistry and the possible routes to such careers. As might be expected, CTNG activities with a specific focus on careers, such as Chemistry at Work, produced strong impacts of this nature and contact with 'real chemists' is deemed important.

Understanding of chemistry courses in HE – a small proportion of the pupil interviewees feel they have a vague understanding of chemistry courses in HE from their experiences as part of CTNG activities. However, most feel these experiences served only to give them basic, or introductory level information, rather than much detail, suggesting chemistry in higher education was not a major aspect of the activity they experienced.

Teacher and coordinator views

Teachers also feel that Strand 1 activities give pupils a **better understanding of what they can do with chemistry**, and what university environments are like, which in turn make them more motivated to attend university. Such additional experiences are also felt to be useful in relation to young people's UCAS applications. Again, like the pupils, they highlight the **value of contact with undergraduates and post-graduate students** who serve as young, relevant role models and effective counter balances to stereotypes and misconceptions.

Similarly, regional coordinators indicate that one of the most evidenced impacts on pupils, as a result of their exposure to the CTNG project, is on their **awareness of higher education** generally (e.g. 5 of the 6 regions rated this item of impact with a 4 or 5 on the rating scale). However, regional coordinators also agree with the pupil responses, to suggest less prevalent impacts from CTNG activities on pupils' awareness of chemistry in higher education and even less so on their awareness of chemistry careers.

Attitudes and perceptions of chemistry

The initial questionnaire asked pupils to rate the extent to which their experiences of chemistry interventions, such as CTNG have made a difference to their attitudes and perceptions of chemistry. Their responses are presented in Table 3.5.

Table 3.5: Impact ratings: Strand 1 pupil survey sample

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Understanding of relevance/usefulness of chemistry	3	15	28	38	13	3.5
Enjoyment of chemistry in school	7	14	31	28	16	3.3
Attitudes towards or perceptions of chemistry	7	10	36	32	11	3.3
N=110						

Source: NFER pupil survey, 2007-08
A total of 106 respondents gave a valid response to at least one of these items

The table above shows that pupils gave average ratings of 3.5, 3.3 and 3.3 for each of these items. Fifty-one per cent of pupils feel their experiences of CTNG activities have impacted positively on their understanding of the relevance and usefulness of chemistry (i.e. rated 4 or 5). Accordingly, this impact constitutes one of the strongest impacts of the CTNG strand. Forty-four and forty-three per cent of pupils rated strong impacts of Strand 1 on their enjoyment of chemistry in school and attitudes towards or perceptions of chemistry.

Pupil views

Similar proportions of the interview sample report positive impacts in these areas, highlighting, like the survey sample, particular benefits in terms of their enhanced understanding of the relevance and usefulness of chemistry.

Understanding about the relevance and usefulness of chemistry – nearly all the interview sample (18 out of 20) report strong impacts from the CTNG activities in this regard. Pupils have a better understanding of the variety of applications of chemistry, what it's used for and how important chemistry is in everyday life as a result of their experiences as part of CTNG. One pupil comments: '*It's in everyday life, it's everywhere around us. It's not just something you learn - like I do maths but I probably won't use half of it later on in life and I'll forget most of it, where as chemistry is everywhere*'.

Enjoyment of chemistry – for half the interview sample their experiences of CTNG has a positive impact on their enjoyment of school chemistry. CTNG activities helps pupils understand more about chemistry, chemical reactions and causes and helps them become more interested in chemistry due to an appreciation of the applications of chemistry beyond the classroom.

Teacher and coordinator views

According to teachers, one of the most notable impacts of the Strand 1 programme is on pupils' attitudes towards, and perceptions of, chemistry. Strand 1 activities give pupils **insights into how interesting and exciting chemistry can be**, particularly because more adventurous and stimulating experiments can be undertaken during such activities than in the school environment. One teacher comments:

> *Quite a few of them have re-evaluated their view of sciences. Obviously those that went on the trip have now had to make some decisions on their future and I think it has given them a better idea of what's available for science careers and the fact that chemistry isn't always boring and there are a lot of practical aspects of chemistry. I think these activities do focus the youngsters on different aspects of chemistry and not just – if I do a chemistry degree I'm going to be a teacher. I think long term it has, it's really opened their eyes to what is available.*

Drawing on wider data and experience of other Strand 1 activities, additional outcomes are reported by the CTNG national manager. For pupils, these include **raising awareness as to what chemistry in the real world**

incorporates, enabling pupils to undertake practical work which they have not been able to do in school due to a lack of equipment (e.g. using a spectrometer in a spectroscopy day), positively changing young people's perceptions as to the work of chemists and the range of career opportunities available. Drawing on pupil feedback responses and their own and teachers' perceptions, regional coordinators also indicate that CTNG activities have a positive impact on pupils' **understanding of the relevance of chemistry to everyday life** and enjoyment of chemistry (e.g. in most regions these impacts were rated with a 4 or 5). For instance, pupils are felt to be more aware of the chemistry around them and of the misconceptions about chemistry construed in the media and amongst the general public, as well as greater awareness of the prospects associated with chemistry study.

Future intentions and participation in chemistry

The initial questionnaire asked pupils to rate the extent to which their experiences of chemistry interventions, such as CTNG have made a difference to their future intentions towards further participation in chemistry study and chemistry careers. Their responses are presented in Table 3.6.

Table 3.6 shows that pupils' experiences of Strand 1 activities have led to a positive effect on their future intentions towards further study and careers (mean rating 3.6). This is the second strongest impact of the strand. Strand 1 is most likely to affect pupils' intentions to go to university and to a lesser extent their intentions to study chemistry, and to a lesser extent still, their intentions to chose a career in chemistry. However, for over a fifth of pupils, the university and outreach strand has a strong positive impact on their future intentions towards chemistry (e.g. 30 per cent and 22 per cent of pupils rated 4's and 5's indicating impacts on future intentions to study and take a career in chemistry).

Table 3.6: Impact ratings: Strand 1 pupil survey sample

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Future intentions (e.g. further study/career plans)	6	11	24	36	21	3.6
Future intentions to go to university/higher education	16	10	26	26	17	3.2
Future intentions to study chemistry	18	21	26	18	12	2.8
Future intentions to take a career in chemistry	22	22	30	17	5	2.6
N=110						

Source: NFER pupil survey, 2007-08
A total of 106 respondents gave a valid response to at least one of these items

Pupil views

Qualitative discussions with pupils during interviews also indicate that the Strand 1 project is having a positive impact on at least some pupils' future intentions. Overall, the pupils interviewed showed some greater inclination to consider further participation in chemistry, although often definitive plans were not asserted.

Impact on likelihood to take chemistry further as a subject – three quarters of the interview sample of pupils (15 out of 20) say that they are now more likely to take chemistry further as a subject following their experiences of the university and outreach strand. Pupils say they have realised how interesting and fun chemistry can be, as well as gained more ideas about what you can do as a result of studying chemistry. Although some pupils feel the Strand 1 activities have had no affect on their future study plans (e.g. chemistry is not for them or they have already chosen alternative subjects), there is evidence that the activities widen the possibilities pupils' consider in such decision making and help to bring chemistry into the frame, as this pupil comments: '*Definitely* [more likely to take chemistry further as a subject], *I wasn't even thinking about it before* [the CTNG activity]'.

Impact on likelihood to take chemistry for a career – half of the sample (10) report that they are more likely to take a career in chemistry following their experiences of activities as part of the university and industry outreach programme. Pupils believe the activities have shown them what kinds of careers are available within chemistry and that these careers seem appealing and attractive, which often they had not been aware of before. Where this impact is not evident, pupils have other career options they would rather pursue.

Impact on likelihood to go to university/higher education – slightly fewer pupils feel their experiences of Strand 1 have affected their intentions to go to university, with eight of the interviewed pupils now being more likely to go having found out more about it, for instance: '*I'm definitely going to go to university, there's loads of different reasons why but going and seeing that university and talking to the uni lecturer has really helped me decide*'. Pupils for whom the intervention has made no change had usually intended to go to university anyway.

Teacher and coordinator views

Interviewed teachers agreed that the Strand 1 programme has considerable scope to impact positively on pupils' future intentions towards chemistry and higher education. They suggest that the experiences help pupils to create a more diverse personal world map where university and science further study and careers become possibilities they have perhaps not greatly considered before. One teacher explains: '*What I can say is that some of them who weren't intending to go to university are probably now going to go to university, their views have changed*'.

In addition, the CTNG national manager and some regional coordinators have received informal feedback from schools to suggest that, as a result of participation in the CTNG programme, pupil take-up of AS and A-level chemistry is increasing. For some young people, impacts also include an increased interest in studying chemistry or pursing it as a career or a confirmation that this is the right direction (on the other hand, for others, participation has led them to a decision that chemistry is not for them). Furthermore, in 2008 there has been an increase in overall numbers of applications to chemistry courses in higher education and admissions departments anecdotally suggest that they are receiving more applications from schools involved in outreach activity (though attribution of such impacts to the input of the CTNG programme remains a challenge).

3.5.2 Findings from the CTNG database of feedback forms

In 2005 CTNG collaborated with three other Aimhigher initiatives to produce a joint database in which to submit individual student feedback forms from young people involved in CTNG activity from 2004–2008. At present, the database holds around 7,000 individuals' responses. The NFER researchers explored a selection of the questions and answers in the database, in order to gain a wider picture of the impact of CTNG activity on young people's attitudes and intentions.

The findings presented here are from researcher analysis of the extent of shifts in attitude towards higher education and chemistry careers amongst the young people participating in CTNG activities and events. We focused particularly on the extent of changes from negative to positive attitudes following CTNG activities.

Impacts on intentions to go to university and HE

Researchers analysed the responses to the questions: 'Before attending today, were you considering going to University or another Higher Education Institution?' and 'After attending today, are you more likely or less likely to consider going to University or another Higher Education Institution?'.

- Of those young people who answered that before the CTNG activity/event they were 'definitely not' considering going to university (90 young people), 27 (30 per cent) indicated that following the CTNG activity they were now 'more likely' to consider going to university or higher education.
- Of those young people who answered that before the CTNG activity/event they were 'probably not' considering going to university (335 young people), 165 (49 per cent) indicated that following the CTNG activity they were now 'more likely' to consider going to university or higher education.

Impacts on intentions to go into a career in chemistry/chemical sciences

Researchers analysed the responses to the questions: 'Before attending this event, were you considering a career in chemistry or the chemical sciences?' and 'After attending this event, are you less likely or more likely to consider a career in chemistry or the chemical sciences?'.

- Of those young people who answered that before the CTNG activity/event they were 'definitely not' considering a career in chemistry or the chemical sciences (464 young people), 69 (15 per cent) indicated that following the CTNG activity they were now 'more likely' to consider going into a career in chemistry.
- Of those young people who answered that before the CTNG activity/event they were 'probably not' considering a career in chemistry or the chemical sciences (1184 young people), 367 (32 percent) indicated that following the CTNG activity they were now 'more likely' to consider going into a career in chemistry.

Analysis of the effectiveness and usefulness of the CTNG activities

Researchers explored three further questions on the database to provide further exemplification of young people's perceptions of the effectiveness and usefulness of CTNG activities overall.

- 2,277 young people gave a valid response to the question: 'Overall, please indicate how useful you found today'. Forty-six per cent of these young people rated the CTNG activity they had experienced as 'very useful' and 45 per cent rated that they had found it 'quite useful'. Only eight per cent of the 2,277 valid respondents indicated that the CTNG activity had been 'only slightly useful' and one per cent said that it was 'not useful at all'. This suggests that the vast majority of young people found CTNG activities useful overall.
- 1,258 young people gave a valid response to the question: 'Would you recommend this series of activities to other students in your year group?' Ninety-two per cent of these respondents said that they would recommend the CTNG series of activities to their peers.
- 4,900 young people gave a valid response to the question: 'Did the activities teach you anything about studying at a University or Higher Education Institute?' The vast majority of these young people (87 per cent) indicated that CTNG activities had taught them something about studying at university or higher education. The remaining 13 per cent did not feel the CTNG activities had taught them about university or higher education.

The findings indicate that CTNG activities can encourage young people to consider the option of university and a career in chemistry when previously this had not been an intention. The findings also suggest that, overall, CTNG activities are effective at raising young people's awareness of, and insights into, higher education.

3.5.3 Outcomes and impacts for pupils over time

Questionnaires were collected at two time points with a subset of the pupil survey sample (46 pupils), during the autumn term 2007 (following some initial CFOF participation) and during the summer term 2008 within the same academic year. All of these pupils had experienced chemistry enrichment activities as part of the Strand 1 programme at the time of the initial survey. It was not possible to collect follow up data from the entire survey sample due to the timing of the follow-up survey in the summer term, when often pupils had left for the year following early examinations. In this section the responses of the subset sample to the initial and follow-up questionnaire are compared in order to gauge the extent of longer term impacts and sustainability of impacts from participation in chemistry enrichment activities, over time. (It should be noted that pupils may have been involved in other outreach activity during the course of the year, though they were not understood to have experienced any further CTNG activities.)

Table 3.7 compares the pupils' responses to a list of attitude and intention statements around chemistry in the initial questionnaire and follow-up questionnaire. In both questionnaires, pupils were asked to rate their extent of positivity to each statement on a scale of 1 to 5. The dark shaded rows indicate where pupils ratings are particularly lower in the follow-up survey. The lighter shading indicates where pupils' ratings are slightly higher in the follow-up survey.

Table 3.7: Comparison of follow-up ratings with initial ratings

Statement	No. of pupils giving higher rating	No. of pupils giving same rating	No. of pupils giving lower rating
I am not/am doing well in chemistry	10	13	18
I do not enjoy/do enjoy chemistry	16	9	17
Chemistry is hard/easy	11	9	22
Chemistry is not useful/is useful for everyday life	13	13	16
Chemistry is not useful/is useful for jobs/careers	10	11	20
I do not like/do like the way chemistry is taught	8	11	22
I don't know/do know a lot about what chemists do	12	12	17
I am not aware/am aware of a range of chemistry careers	9	12	20
I don't know/do know a lot about higher	16	15	11

education			
I do not/do feel prepared for higher education	13	14	15
I do not intend/do intend to go to university	15	18	9
There aren't/are interesting/exciting chemistry careers	10	14	18
I do not intend/do intend to take chemistry further as a subject	17	7	18
I do not intend/do intend to take chemistry for a job/career	15	10	17
Your attitudes towards/perceptions	10	15	16
Future intentions to go to University/HE	17	10	14
Future intentions to study chemistry	17	13	11
Future intentions to take a career in chemistry	20	6	15
N=46			

Source: NFER pupil survey, 2007-08
Up to 5 respondents did not respond to items of this question in the follow-up survey

The table above shows that for around half of the statements, pupils' ratings are slightly **less positive in the follow-up questionnaire** than in the initial questionnaire. For instance, pupils give lower ratings for how well they are doing in chemistry, how hard they find chemistry, liking of the way chemistry is taught and their awareness and perceptions about chemistry careers, in the follow-up question compared to the initial questionnaire (i.e. darker shaded rows on the table). This suggests that such attitudes are most strongly impacted by the activities in the short term, and that over a longer time period the impacts begin to diminish slightly.

For other statements, the pupils' views in the follow-up question are more divided, with roughly equal proportions rating similarly, more positively or less positively than in the initial questionnaire. Overall, around a quarter to over a third of the follow-up sample rate higher impacts than in the initial questionnaire, suggesting sustained and longer term impacts are possible for some pupils. Pupils are more likely to rate their awareness of higher education and intention to go to university the same or higher in the follow-up questionnaire, indicating that such positive attitudes are sustainable over time. Interestingly, pupils gave slightly higher ratings in the follow-up questionnaire to indicate that they are even more likely to go to university, study chemistry and take a career in chemistry (i.e. lighter shaded rows on the table). These findings suggest that, **for some pupils, positive attitudes instilled by**

chemistry interventions can endure in the longer term and this indicates the potential of such experiences to influence future thinking and intentions.

However, in interpreting these findings it is important to be extremely cautious and bear in mind both the small sample size (46 pupils) and the vast range of other experiences pupils are likely to have encountered between the two time points, which may be responsible for affecting attitudes towards chemistry (both positively and negatively).

3.5.4 Outcomes for teachers

This section explores the outcomes of Strand 1 on participating teachers. Teachers gave their views on what they thought of the University and Industry Outreach to Schools project for themselves. Data are drawn from five teacher interviews and four teacher follow-up interviews; proforma returns from six regional coordinators, and; interviews with the CTNG national manager.

In general teachers comment that the main outcomes of their involvement in the activities are: opportunities to develop their relationships with the pupils in a different environment and setting; new curriculum resources and ideas for teaching activities, and; new links with universities.

The teachers were asked to respond, on a scale of 1–5, to a series of questions to ascertain whether the activities had made any difference to their professional development, and to provide details. Three areas of impact are rated particularly highly by the teachers:

- their **access to resources and materials** – teachers are given resources, e.g. handouts, DVDs, new ideas and web resources at the activities and events and also referred to people and contacts as a resource and source of support and advice
- the schools' **links with HEIs/industry/other schools** – increased links have been forged between the case study schools and HEIs and, though to a lesser extent, with industrial partners and companies and other schools (e.g. one of the case studies involved partner work with other schools as part of STEMPOINT CREST award)
- the **profile of chemistry in the school** – this is being raised by CTNG activities within the science department and more widely across the school. One teacher notes *'… the profile of science is quite high within the school and it's simply because we are doing so many of these visits and so many of these activities within the school. I don't think our profile would*

have been as big if STEMPOINT and yourselves (CTNG) hadn't been involved'.

Other areas of impact that are rated reasonably highly, although not as strongly as the above, are:

- their own **chemistry teaching** – teachers pick up ideas, activities and practicals while participating in Strand 1 events to aid their teaching of chemistry, as one teacher describes: '*I also get to learn some things as well, like making soap, I didn't know how that was done, I asked them how, as a teacher, I could do it in school and they gave me a recipe, so I've already used it with the science club'*. This may be a particularly important outcome and source of support for non-specialist chemistry teachers. Teachers also mention that they are able to relate aspects of the curriculum (particularly more abstract concepts) to the practical work undertaken as part of the initiative, thus aiding delivery.
- their **capacity to support and advise their pupils** regarding further chemistry study and careers – teachers access to up to date information from universities and contact with HEIs and chemists working in industry.
- teaching of **practical lessons/experiments** – some teachers explained how they had used ideas picked up at chemistry events and activities back in their lessons.
- awareness of **chemistry careers** – not especially reported, but teachers occasionally gained in this way, e.g. in terms of up-to-date knowledge of chemistry courses in HE, various pathways and awareness of how chemistry careers can be creative (through an art and chemistry event)
- **knowledge of chemistry**/chemical science – not especially reported, but some teachers indicated slight benefits in terms of increased knowledge of particular chemistry topics, e.g. nanotechnology and knowledge of different approaches to chemistry teaching and experiments as well as updates in techniques since the teacher's own training.

Two further possible impacts for teachers were explored, but are generally rated lower than those outlined above:

- their **confidence to teach chemistry** – as one teacher said, it has given them more experiences to draw on as a teacher
- their own **career development** – although it was noted that such impacts can be to do with the kind of teachers who get involved in such activities, namely those who are enthusiastic to get involved in such initiatives

The CTNG national manager also feels that impacts are gained by teachers through their involvement in the events and activities. These include: a knowledge refresher, an increased understanding of the application of chemistry in the workplace, and an increased understanding of how chemistry is taught in higher education. Likewise, regional coordinators suggest that there is scope for positive impacts on teachers involved in CTNG activities, though perceptions about the extent of such impacts vary across the six regions. According to discussions with teachers and their responses in feedback, moderate to strong impacts were evidenced on teachers': awareness of higher education, knowledge, skills and teaching practice, confidence to teach chemistry and awareness of chemistry in higher education and chemistry careers. Individual regional coordinators also indicated that the activities have motivational impacts on teachers and that teachers value the opportunity to make links with HEIs (universities and colleges) and are increasingly becoming aware of the STEM enrichment opportunities available through contact with the CTNG project.

It would seem that CTNG activities contribute towards impacts that build teachers' capacity to work with outside partners (e.g. universities), and to make use of new ideas and learning back in the classroom. It would also seem that teachers stand to gain significantly from CTNG activities which are essentially designed for and targeted towards pupils, suggesting that the activities being delivered as part of CTNG have a range of subsidiary effects on teachers.

3.5.5 Outcomes for others

According to the CTNG national manager and regional coordinators, there are also **positive outcomes on HEI staff** as a result of their involvement with the events and activities. Such impacts include an **increased understanding of the curriculum** taught in schools, which has influenced induction and initial lectures, and involvement in an enjoyable outreach activity which has enabled staff to be creative and innovative. One regional coordinator reports that CTNG has **raised the profile of schools' outreach amongst chemistry departments**, encouraging other departments to get involved. Furthermore, for some postgraduate students involved in supporting and delivering CTNG activities, the experience of working with school pupils has given them insights into school teaching as a career pathway, as well as aided the development of other skills, such as presentational skills, and in at least one instance this has led to the successful pursuit of such a career.

Greater collaboration between HEIs is also a beneficial outcome. As one regional coordinator reported, CTNG activity '*encourages all HEIs to share best practice and demonstrates a uniformed approach to recruitment. Rather than competing for the same students, all HEIUS are collectively increasing the number of prospective applicants studying chemistry*'.

There are also felt to be general benefits to the STEM community, in that regional coordinators are increasingly being viewed as knowledgeable sources of chemistry outreach information and expertise and have an important role to play in partnership working around STEM within localities.

3.5.6 Outcomes summary

Table 3.8 summarises the types and prevalence of various outcomes on pupils as a result of their experiences of events and activities as part of the University and Industry Outreach to schools programme (focused on CTNG).

The activities are clearly having a positive **impact on pupils**. The strongest impacts of this strand appear to be on:

- pupils' awareness of HE
- pupils' future intentions (e.g. future study and career plans)
- pupils' understanding of the relevance and usefulness of chemistry.

Where the impacts are strongest, the strand also has the capacity to influence pupils' future intentions and increase the possibility that they will participate in chemistry further.

Table 3.8: Overall rank order of impacts: Strand 1

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Awareness of higher education	5	7	26	38	21	3.7
Future intentions (e.g. further study/career plans)	6	11	24	36	21	3.6
Understanding of relevance/usefulness of chemistry	3	15	28	38	13	3.5
Chemistry knowledge and skills	2	15	32	38	8	3.4
Enjoyment of chemistry in school	7	14	31	28	16	3.3
Attitudes towards or perceptions of chemistry	7	10	36	32	11	3.3
Future intentions to go to university/higher education	16	10	26	26	17	3.2
How well you're doing in chemistry in school	8	13	36	32	8	3.2
Awareness of chemistry careers	7	21	31	29	8	3.1
Awareness of chemistry in higher education	9	22	35	25	6	3.0
Future intentions to study chemistry	18	21	26	18	12	2.8
Future intentions to take a career in chemistry	22	22	30	17	5	2.6
N=110						

Source: NFER pupil survey, 2007-08
A total of 110 respondents gave a valid response to at least one of these items
The items are ranked by mean rating and then number of 4 and 5 ratings.

CTNG activities contribute to positive **impacts on teachers** involved in terms of enhancing:

- access to resources and materials
- links with HEIs/industry/other schools
- the profile of chemistry in the school.

Where the impacts are strongest on teachers involved, there is also the capacity to impact positively on chemistry teaching, including providing teachers with ideas, knowledge and awareness to help support and enrich their chemistry teaching.

The CTNG project has also contributed to **impacts on others and the availability and quality of STEM outreach**, including:

- positive outcomes for HEI personnel (e.g. postgraduate career development and academic teaching staff awareness of educating school pupils)
- the way universities are delivering outreach to schools, encouraging them to engage with a wider cohort of pupils in more effective, innovative ways, working with a wider age range and different types of schools
- the extent of collaboration amongst HEIs to deliver outreach to schools (where historically there may have been more competition and rivalry)
- more chemistry activities being delivered in the six regions and universities have been encouraged, with the funding, to explore new ways of engaging young people, as well as more collaboration with other institutions
- raised the profile of schools' outreach in higher education departments, encouraging other schools to get involved
- established regional coordinators as a point of contact for schools and other partners and provided a sense of branding which contributes to raising awareness of chemistry generally. The CTNG project has an established reputation for high quality outreach, has improved collaboration in the regions between universities and draws on local knowledge to ensure improved availability of outreach. The reputation and embedding of these activities in the local STEM contexts will aid the long term sustainability of the project.

3.6 What works and lessons learnt

What works well?

The case study interviewees, regional coordinators and the CTNG national manager were asked about aspects of the Strand 1 activities that work well. **Practical activity** and **hands-on pupil participation** are by far the most commonly cited features that pupils, teachers and coordinators feel work well. Pupils appreciate the opportunity for **interactive, practical and visual demonstrations** and presentations.

Within the case study schools, interviewed pupils also feel the following features work well: **a balance between practical and theory**, **group work**, the opportunity to use **facilities and equipment** that they do not have at school, a chance to **meet new people**/work with pupils from other schools and for **contact with 'real chemists'** (exposure to people doing chemistry in the real world and beyond the classroom), a chance to be **away from the classroom** and learn in a different environment and have **contact with university and university students** to get a sense of what it is like. Some pupils appreciate that the activities are new and cover topics that they have not done before, whilst others feel that activities work best when they relate back to something they have done in their classroom chemistry.

In addition, teachers feel that activities work well when there is **teacher involvement**, and when the activities give them **ideas and resources to take back to the classroom**.

Drawing on wider data from across Strand 1, reports from the regional coordinators and CTNG national manager suggest that many activities are extremely popular and are usually fully, if not, oversubscribed. The following features seem to work well:

- the opportunity for young people to have **hands-on and practical experiences** with opportunities for interaction
- activities that are relevant to the young people and **relate to and fit into the curriculum**, to promote learning and ensure usefulness
- activities **delivered by multiple institutions** with **representation from chemical industry and employers** that are **attended by pupils from a range of schools**, creating opportunities for partnership working and providing a range of people for young people and teachers to interact with (e.g. Chemistry at Work, events run at Science Learning Centres, The Synthesis events)
- opportunities for pupils to handle and learn how to **use the equipment themselves** (e.g. spectroscopy days)
- the opportunity for young people to **visit university settings** and gain an understanding as to what university life is like. Though, equally the availability of some **school-based events** is valued, particularly in terms of reducing transport costs and other barriers
- a chance to **experience chemistry in the real world**, such as through practical, lab based activity and access to real chemists and chemistry students
- activities that are **sustainable and long term** are important as they become increasingly well known and teachers can plan in advance to book places
- **the timing of activities** is also a key feature, take up of activities is particularly high during the autumn term and late summer term

- **summer school activities** are very popular and provide opportunities for more intense, participative experiences.

At this stage in the evaluation, the data does not reveal whether **group size** makes a difference in terms of what works best (i.e. whether large scale stadium events or small scale hands-on events work best). However, the young people's positive views of interactive, hands-on activities suggests that smaller-scale events are perhaps more beneficial, as here, young people are able to have an active role in activities.

Good practice is noted around the extent of **collaboration and multi-agency working** that is being achieved in delivering the CTNG project. Relationships and understandings are being built between schools, HEIs, industry, employers and STEM organisations, indeed where there has not always been a history of such collaborative approaches. Many activities involve collaborative work between agencies, which are particularly beneficial to pupils in terms of giving them insights into the varying elements and applications of chemistry, and enabling the **sharing of good practice** across the institutions and partners. During 2008-09 there are plans to move further in terms of providing collaborative STEM activities, incorporating science, technology, engineering and mathematics. Good practice is also noted around the development of **new and innovative activities** and events. Across the six regions, portfolios of successful CTNG activities are being established. Regional coordinators advocate the importance of making **quality careers information** available at such events.

Feedback from members of the CFOF Steering Group and Project Advisory Group also reiterated the following key features as working well in this strand:

- the experience of the **original three CTNG pilot regions** has helped with the set up, management and delivery of CTNG in the three new regions
- the **CTNG regional coordinators' role is key to engaging schools** in outreach activities. Their organisational role and keeping in touch with schools is important: an industrial partner we interviewed noted this role as vital as industry does not have the capacity to network with schools on a day-to-day basis
- a 'good team spirit' is reported amongst Strand 1 regional coordinators.

Challenges, barriers and suggested improvements

Few challenges and barriers are reported by the case study pupils and teachers in relation to their involvement in Strand 1 activities. However, a few pupils and teachers have commented that some of the lectures and demonstrations would have **benefited from more time**, and a couple of pupils feel that events involving a large number of young people (such as those in a big lecture hall) had **discouraged them from feeling that they could ask for help**. **Making practical arrangements** for pupils to be out of school is also identified by teachers as a challenge. Pupils would also like to do activities **more often** and to experience **different types of activities**.

Pupils suggest the following improvements for the Strand 1 activities (with the most popular listed first): to involve even more practical activity, to involve even more pupil participation, to provide **more time** for practical sessions, and to provide more opportunity to **'taste' the wide/full range of chemistry** activity at university.

Drawing on wider data and experience of other Strand 1 activities, challenges reported by the regional coordinators and the CTNG national manager include the following:

- **timing and timetabling** – the timing of events seems to significantly impact on attendance, for example, attendance is lower around GCSE and A-level exam and mock exam times; though take up is high in the autumn term and late summer term (particularly November and July)
- **teacher attendance** – to deal with the constraints of the school day, in some cases A-level school pupils have attended events without being accompanied by their teacher. In these cases, agreement in advance has been sought from parents.
- **preparation time** – this needs to be factored in and to allow schools to plan in advance the activities that their pupils will be involved in over the course of the academic year
- **time and costs for school transport** can be an issue, though this can be alleviated to some extent with CFOF covering transport costs or activities and events being delivered on school sites
- schools **dropping out of events at short notice**. To counter this, some regions have set up a booking fee system although not all are comfortable with this approach
- the regional coordinators have also found it a challenge to **engage FE colleges** and there has, generally, been a poor response from the FE sector to the activities and events that have been organised

- the engagement of a sufficiently broad range of **industrial and employer partners** (including smaller organisations) involved in planning, supporting and delivering activities and events. Indeed, the need for **greater emphasis on careers activities** and information at events has been raised
- work is continuing to develop the chemistry outreach activities available for **younger age groups**. HEIs have traditionally had less experience and involvement in teaching this age group
- the process of **exploring new types of events** and activities is inevitably challenging and key elements to success inherent in all activities are felt to be good teaching practices, as well as an active pace and involvement of the young people. Where these ingredients are less evident the activities have not worked so well.

In addition, the CTNG national manager has commented that there are still some **schools not engaged in the project**. There are plans for the 2008-09 extension year to adopt a much more direct approach to communicating with such schools, with more face-to-face contact in order to explore the barriers to engagement in the programme and what could be done to overcome such issues.

The challenge of identifying **accurate costs of activities** is also recognised as activities are often considerably subsidised by university and other partners with ‘in kind’ support (e.g. staff time). Impending changes to university financial structures to full economic costing models, whereby universities may have to recover overheads for such outreach work, are expected to impact on the sustainability of projects such as CTNG.

3.7 Additionality

CTNG funding has resulted in the running of additional activities within the six regions which it is felt would not have been delivered in the absence of the programme. The Regional Steering Groups have ensured that activities organised have met existing needs and gaps in provision and have generally not duplicated provision coordinated through other partners such as Aimhigher or STEMNET. In many cases, provision funded through other providers tends not to be chemistry-specific which has reduced the chance of duplication. Through co-funding activities with Aimhigher, CTNG funding has also enhanced and increased the scale of activities and events already in the pipeline.

3.8 Next steps

Funding has been made available for an extension year of the Strand 1 project from 2008-09. In the extension year the budget available for each region will be increased from £30,000 in 07–08 to £45,000 and the decision to engage with more nationally based deliverers has been devolved to the regions. The target for the year 2008-09 is to work with 15,000 pupils.

During the extension year there are plans in place in some regions to target activities towards different progressions routes (e.g. BTEC students), as well as develop family learning activities, in order to further widen participation.

There are also plans in place to produce 13 new CTNG resource packs, some of which will be more cross disciplinary within STEM in order to work towards a more integrated and coherent STEM project from July 2009 onwards (e.g. National STEM HE programme). Accordingly, regional coordinators are forging links with engineers and mathematicians within their regions.

Further work is also planned to engage remaining hard to reach schools, through more direct contact initiated by the regional coordinators to try and explore and eliminate any barriers to participation in the project.

In addition, work is also planned to continue to surmount challenges discussed above in terms of engaging STEM stakeholders and partners.

4. Strand 2: Supporting Key Educational Interfaces – a Teacher Fellowship Scheme

This section presents the findings from year one of the Teacher Fellowship Scheme. It takes into account data collected prior to the production of the interim report in January 2008, and draws on a further body of data gathered in the first half of 2008 (up to and including the end of the summer term).

Three year-long, full-time teacher fellows and two part-time (one day a week) fellows were in post for the academic year 2007–2008. Two other full-time fellowships started in January 2008 – for one, and two terms.

4.1 Key findings

Impacts for host universities.

Teacher fellows have:

- made a considerable **impact on their host departments'** understanding of school curricula, school teaching practices, and the capabilities of incoming students.
- facilitated the development of resources and **implementation of departmental strategies** to address identified gaps in students' confidence, knowledge and skills.
- **opened up a debate on teaching and learning** in the department and played an important role in the review and refinement of course structure, content and delivery.
- impacted **beyond the host department**, for example, through being invited to participate in university-wide working groups in which they have assisted with the wider challenge of enabling students to become self-directed and independent learners.

Impacts for teacher fellows.

Teacher fellows feel that:

- the fellowship has had a considerable impact on their **capacity to inform and advise** students about studying chemistry at higher levels, and an impact on their own awareness of chemistry careers and graduate destinations.
- the fellowship has led to the development of their **skills and knowledge**, and **renewed their enthusiasm** for the discipline.

Impacts for schools.

- Teacher fellows have worked hard to encourage **closer relationships with schools**, and almost all their academic hosts report that if the fellowship has not already had a positive impact on relationships with local schools, it is expected to do so in the future.
- The wider benefits of the teachers' new skills, knowledge and enthusiasm (for example, on schools and pupils) will be explored in the next phase of the evaluation.

How well it works

- Whilst the scheme has had many positive impacts, it has also had some more **negative consequences**, particularly for fellows' schools, where the loss of a good teacher has been felt keenly.
- A range of factors have a bearing on the success of the programme: the **outlook and culture** of the host institution; the personal and professional characteristics of the teacher fellow; the planning of the placement; and the recognition and utilisation of accumulated expertise.
- The **part-time model** may be the most manageable for schools, although this did not find quite as much favour with fellows and universities, and was not what early anecdotal evidence had led the RSC to anticipate.

Implications

- Evidence across the scheme suggests that, from a reasonably small starting point (i.e. seven teacher fellows) (and a reasonably small investment), **a wide 'net' of impacts is possible**, reaching HEIs and schools beyond those most immediately involved.
- There is a considerable enthusiasm for the fellowship scheme as a whole, and for extending each placement from one to (a maximum of) two years; however, more attention needs to be given to **minimising the costs and maximising the benefits to teacher fellows' own schools**.
- In addition, the teachers who would make effective teacher fellows are the very teachers schools would be reluctant to release. However, as pointed out above, the scheme need not involve a vast number of fellows for it to generate wide and generally very positive impact.
- One area where **further activity** and evaluation may be needed is in **raising awareness of chemistry opportunities amongst students and parents** (aim 3). Consideration of how this can be addressed will be important if the third aim of this strand is to be fully achieved.

4.2 Introduction to Strand 2

Strand 2 is a fellowship scheme for teachers. The main aims and objectives of this strand are shown in the following box.

The aims of Strand 2 are to:

- improve academics' knowledge of: the content of A-level chemistry and GCSE science courses; current teaching practices in schools; the types and range of pedagogy used; the practical work undertaken by students and the capabilities of incoming undergraduates.
- develop strategies for bridging the gap between school and university chemistry courses, both in terms of content and practical experience.
- raise awareness amongst teachers – and students, their parents and guardians – of what it is like to study chemistry at university, the benefits of higher education and the career options available to chemical science graduates.
- develop sustainable links between schools and universities.

The year-long (full-time and one-day-a-week) fellowships started in September 2007, with the one and two-term fellowships starting in January 2008. The universities involved in the pilot year were: Sheffield, Nottingham, Warwick, Birmingham, Bath, Leeds and Reading. The total budget for this year and strand was £282,000.

The evaluation involved interviews with seven teacher fellows early on in their fellowships; follow up data collection with the teacher fellows in July 2008 by phone or e-mail; questionnaire proformas with six of the seven HEIs, and four of the fellows' schools; and telephone interviews with the RSC coordinator for Strand 2.

4.3 Strand management

The Strand 2 Teacher Fellowship Scheme is managed by staff members at the RSC. Each teacher fellow has been assigned a line manager within their university chemistry department. In general, it is felt that the strand is being well managed. Teacher fellows have found the RSC to be responsive, flexible and accommodating to any requests for support. Teacher fellows provide regular updates (fortnightly for year-long fellows and monthly for part-time fellows) to the RSC and are able to flag up any issues promptly. Teacher fellows describe regular contact from the RSC as facilitating the exchange of ideas and best practice.

4.4 Progress and outcomes: the ambitions and achievements of Strand 2

The Strand 2 Teacher Fellowship Scheme has four distinct but related aims. It is envisaged that these ambitions will be achieved through the improvement of links and the exchange of knowledge between schools and universities. The teacher fellows are conceived as the catalyst for this process. In this section we consider the evidence to suggest that the fellows have managed to fulfil this brief.

4.4.1 Aim 1: Improving academics' knowledge of students' prior experience and capabilities

The assumption underpinning this aim is that teaching and learning activities are likely to be more successful when they take account of existing knowledge, skills and abilities. An early report from one of the fellows to the RSC suggests that lecturers in their host department were not, at the start of the academic year, really in a position to do this: '*The extent to which many lecturing staff were ignorant of current content and delivery of chemistry education in schools/colleges was significant*'. At the time they submitted that report, the fellow felt that they had had some impact on lecturers' knowledge, but that there was '*still far to go*'.

However, by the end of the academic year when we conducted a follow-up survey of the teaching fellows, all were of the opinion that they had had an impact on their academic colleagues' understanding of school curricula and teaching practices. Most think that they have also enhanced colleagues' understanding of the capabilities of incoming students. Similar views are expressed by their academic colleagues, who we consulted around the same time. They are, on the whole, of the opinion that **the teacher fellows have made a great deal of difference to their department's understanding of school curricula and teaching practices, and of the capabilities of incoming students**.

Impacts on host HEIs

The teaching fellows and their academic hosts are broadly in consensus regarding the impact of the fellowship scheme on the host department, its staff and students. Particularly significant impacts are improvements in academics' understanding of students' prior learning experiences (both content and delivery) and capabilities on arrival at university, one fellow reporting that: '*Staff have found it very useful to have someone who can state definitively what students "should" or shouldn't know (they forget, or appear to forget, a considerable amount over the summer)*'. This understanding – along with the developmental input of the teaching fellows – appears to have been central to the introduction of new learning materials, teaching practices and tools, and programmes (e.g. induction and mathematics) (see section 4.4.4 for more details on these materials).

Reflecting on the past year, one academic reports that their 2007 intake have gelled, progressed and performed unusually well, and it is plausible that the presence and activity of the teaching fellow was a factor in this (though they added the caveat ' *… but it is impossible to prove this correlation*'). Another states that whilst the relationship would be hard to prove, they believe that the '*rejuvenated induction programme*', which is one of the products of the placement, has made a significant contribution to the coherence of the cohort and the unusually high (100 per cent) retention rate at the end of the first term.

For some of the teaching fellows, a major part of their work has involved the development of outreach activities. It seems reasonable to hope that the energy and enthusiasm invested in such activities will have positive results, though it is probably too early to tell what the impact of this has been. As many of the desired outcomes of the scheme will only become evident in subsequent academic years, we asked teachers and academics what impact they *anticipated* the fellowship having in the longer term. Academics' replies show some caution: quite a few anticipate improvements in relationships with local schools and raising the university department's profile in a number of spheres, but they are hesitant about stating that they might expect to see a marked increase in applications to the department (teacher fellows are more willing to do this). Similarly, whilst several expect the refinements to the course made over the fellowship year to result in increases in student satisfaction, they are not sure if this will translate into more students completing their course. One feels that longer-term impact will be contingent on the department being able to retain a teacher fellow.

4.4.2 Aim 2: Developing strategies for bridging the gap

One of the concerns underpinning this strand of the programme is that many students struggle to make the transition from school to university, with gaps in their skills and subject knowledge acting as significant barriers to progress. Aim 2 is underpinned by the premise that such gaps can and should be taken into account more fully in the design and delivery of courses. Part of the fellows' brief is to facilitate the development of strategies to identify and address these gaps.

Most fellows began by clarifying what exactly the gaps in students' baseline skills and knowledge were. This was done through systematic observation and consultation and, in some cases, by mapping degree course content against A-level syllabi. On the whole fellows feel that they have '*been successful in determining precisely the sort of problems undergraduates face at the transition phase'. The* ***most commonly reported issues are with 'maths and practical [laboratory] skills'***.

The next step was to develop strategies to address the identified gaps in knowledge, skills, and confidence. These strategies include: the provision of tailored mathematics support involving differentiation, self-assessment, peer assessment and the employment of personal response systems; new induction programmes including non-assessed 'pre-lab' sessions; and the development of interactive laboratory manuals.

Comments from staff in a number of institutions suggest that **the teacher fellows have played an important role in opening up a debate on teaching and learning**. Their success in engaging the department as a whole in the review of the design and delivery of courses is anticipated to have benefits which outlast their residence and the specific bridging strategies developed.

Finally, whilst some gaps needing to be bridged are specific to the discipline, others relate to the transition to higher education in general and to the challenge of enabling students to become self-directed and independent learners. **In several institutions it has been recognised that the teacher fellow has expertise of value beyond the confines of the chemistry department**. For example, one fellow has been invited to join a university-wide committee reviewing assessment and feedback and other fellows report plans to disseminate learning from the pilot across the institution.

4.4.3 Aim 3: Raising awareness of opportunities in chemistry

The third aim involves improving and extending teachers', students' and parents' understanding of the experience of studying chemistry and the opportunities it might open up.

For teacher fellows, most are of the opinion that the fellowship has had a considerable impact on their personal capacity to inform and advise students about applying for and studying chemistry at higher levels. One comments that the fellowship has '*given me a wider perspective of the role of chemistry in society and enabled me to "see over the hill" to the next stage of education*'. On the whole the fellows feel that there has been quite a positive impact on their own awareness of chemistry careers, the financial returns on these, and graduate destinations beyond research and the chemical industry.

Impacts on teacher fellows

All the teacher fellows reported back on the scheme with immense enthusiasm, with recently gathered data supporting the claims of emerging impacts set out in the interim report (new outlooks, skills, knowledge, and relationships). The personal benefits of participating in the scheme, most particularly as a full-time fellow, were suggested to be considerable and one teacher fellow went so far as to describe the year as '*the most enjoyable and fulfilling of my career so far*'. Another teacher described the fellowship as the best job he had ever had, and a colleague, further on in his career, as '*the cherry on the cake*'. The '*luxury*' of time to experiment and to develop and reflect on the content and practice of teaching was highly valued (one fellow suggesting that the return to a '*frantic school environment*' might initially present some challenges). It was anticipated that their development of new skills and knowledge, and renewed enthusiasm for the discipline, would in time have wider benefits, for example, for their schools and pupils. These sorts of impacts will be explored in the next phase of the evaluation.

For school teachers and school students, the teacher fellowship scheme has raised their awareness of opportunities in chemistry. For several of the fellows, outreach and in-reach work has taken up a significant proportion of their time, and it is hoped that their activities will have significantly increased the department's profile with local schools and communities. One fellow commented that it often appeared to be a struggle (due to time and 'red tape') for school teachers to take full advantage of what the university department could offer. However, the chance for school students to have access to a well-equipped, modern laboratory was said to be valued by many schools. Some of the host departments state that they are looking to try to start opening up their teaching laboratories to schools more regularly in quiet periods. **Some of the fellowships have generated considerable media interest and positive coverage, with this helping to raise the profile of the departments and**

institutions involved (both school and university) and of the discipline as a whole.

No references were made to raised awareness amongst **parents** (i.e. in the sense of perceived impacts on their understanding of chemistry-related opportunities for study and employment). Consideration of how this can be addressed will be important if this third aim is to be fully achieved. For example, are parents involved in any activities stimulated by the teacher fellows? (at this stage, there were no reports of such activities).

4.4.4 Aim 4: Building links between schools and universities

It seems reasonable to think that the in- and outreach work carried out might have contributed to the development of new and lasting bilateral links between schools and the university department. One fellow reports that he has been in contact with more or less every institution in the locality delivering A-level chemistry courses. According to his academic colleagues this includes institutions which the department has approached but found difficult to engage in the past. Overall, **fellows believe that they have been able to encourage closer relationships with and between schools** (more on the latter below) **though one stresses that this is not to say that the department's relationship with schools was poor beforehand**. Most academic respondents feel that the fellowship has made at least a little, and in many cases a great deal, of difference to the relationships they have had with local schools to date, and almost all think their fellow's work will result in considerably improved relationships in the future.

In addition, some **other positive relationships appear to have evolved as a result of the scheme**, for example between one fellow's colleagues in the school's physics department and staff in that area in their host university. The relationships that have developed between fellows have also helped generate new and potentially useful links between the university departments in which they have been based. In addition, activities such as the development of real or virtual networks or forums for chemistry teachers in the locality are thought to have helped foster new relationships *between* teachers in clusters of local schools.

Teaching fellows have:

- developed **new induction programmes** involving quizzes, 'refresher' sessions and modules and 'learning to learn' activities
- produced the **Interactive Lab Primer**, a resource to help students develop the skills and knowledge needed to work safely and productively in university laboratories
- **mapped the content of different A-level courses** against the content of their host department's level 1 and 2 courses
- **adapted the content** of their host department's chemistry foundation course, *inter alia*, by introducing new modules
- **adapted the content** of their host department's first year undergraduate programme, to take account of students prior knowledge
- supported **reviews of students' mathematical skills** and provision to develop those skills
- **promoted the use of WebCT and e-learning technologies** and helped their colleagues to explore how these might be used to engage students and deliver particular aspects of their courses
- **organised networking groups and events** to bring together teachers and lecturers from around the region
- **established a 'buddy' system** through which third year undergraduates provide support to new arrivals
- **delivered workshops and sessions for school pupils** and staff, both on-site (e.g. using the university laboratories) and beyond

4.5 Discussion: lessons and issues from the pilot year

4.5.1 How fully have the aims of this strand been achieved?

Whilst the programme has four central aims, the emphasis of each fellowship has varied and when we asked academics if particular impacts had been evident, or were anticipated, some qualified their responses by saying that those particular impacts were not an ambition of that fellowship, and had not therefore been the focus of activities. So, for example, whilst some fellows were heavily involved in outreach work – contacting schools in the region, arranging visits by schools to the university and vice versa, developing new open day programmes and so on – others worked more exclusively on the review of teaching and learning within the department. **The fellows themselves were instrumental in developing the specific objectives of their placement: most feel satisfied that these had been achieved**.

Where fellows question the extent to which their aims and ambitions for the placement have been fulfilled, it is suggested that it is difficult to achieve all that one hopes in the context of a part-time and / or relatively short-term placement. Even a full-time placement, lasting for a year, might not allow fellows to see an idea through to its full implementation, and certainly not to the point of impact evaluation, and in this respect several fellows have a sense of '*unfinished business*'. The consensus is that '*a one year secondment will only achieve so much*'. However, the fellowships appear to have sown the seeds for new initiatives in the future (for example, the opening up of teaching laboratories to local schools in quieter periods) and it may be that there are further impacts in the future which have their origins in the fellowships of 2007/08.

As noted in section 4.4.3, one area where **further activity** and evaluation may be needed is in **raising awareness of chemistry opportunities amongst students and parents** (aim 3). Consideration of how this can be addressed will be important if the third aim of this strand is to be fully achieved.

4.5.2 The distribution of costs and benefits

In extending the research 'net' to incorporate the experiences and perspectives of participating higher education institutions and schools, it becomes apparent that **whilst the scheme has had many positive impacts, it has also had some more negative consequences, particularly for fellows' schools** (see next box for details). Many interventions have both costs and benefits – these become more problematic to reconcile where, as it seems is the case here, costs are incurred by one organisation (or individual) and benefits are accrued by another.

Impacts on schools

The modest amount of information we received from and about the fellows' schools suggests that for them the benefits of the scheme have to date, in most cases, been minimal (for example, students visiting the host university) or not yet realised, whilst in some cases quite marked costs have been incurred. The loss of an experienced member of staff in a shortage area is reported by one school as adding to the pressure on the relevant department and possibly contributing detrimentally to results at key stage 3 and 4. The basic problem, as they put it, is that '*science teachers are not thick on the ground; good ones even less so*'. So whereas at the time of writing our interim report, the scheme appeared relatively unproblematic in terms of schools coping with the fellows' absence, more recently collected data paints a rather different picture.

Early anecdotal evidence had led the RSC to anticipate that the part-time model would not prove popular. However, whilst the part-time model may not have found as much favour with fellows and universities, the feedback from schools suggests that this might be a much more manageable option for them, and have more immediate returns. Maintaining continuity is considered important, both for pupils and other staff, and one school supplying a part-time fellow reports that they would have found a full-time (term-long) secondment very difficult to accommodate. Another respondent goes so far as to say that (in respect of a part-time placement) the fellow's school would be the key beneficiary.

Where teachers take a full-time secondment, the critical aspect from the school perspective is that they do actually return. Several of our school respondents anticipate benefits in terms of new enthusiasm, skills, knowledge and relationships (in fact it was mooted that, government policy permitting, a formal partnership between one school and university might even be a possibility). However, the realisation of these benefits is contingent on fellows going back into post, which at the time of writing looks certain for only a minority of fellows.

This is not to say that the scheme will not have measurable benefits for schools. However, these benefits will not necessarily be accrued by the schools from which the fellows originated (or at least not exclusively). For example, where the teacher fellow's role has included a significant component of outreach work, university departments have been opened up to a wide range of local primary and secondary schools. Resources for schools on topics new to the A-level syllabi prepared by fellows and their academic colleagues are being made available to any schools that request them and undergraduate 'ambassadors' have, with the support of one fellow, gone out into schools. Several teacher fellows have worked with science PGCE students and / or actively promoted education as a positive career choice, with this potentially impacting on the school workforce in the future. As such, the benefits in terms of access to resources, enrichment opportunities and expertise are real, but diffused amongst a large number of schools.

4.5.3 Have the fellows faced any challenges?

The biggest challenge seems to have been the limited time available to achieve the various objectives. The more limited the time available to a fellow, the more critical it seems that everything is in place ahead of their arrival (an agreed programme, work space, equipment and data access permissions). In addition, a number of practical challenges have been reported – for example, in some institutions work space was very limited and making room for another member of staff was clearly difficult. This said, it was not suggested that this pressure on space compromised fellows' ability to achieve their aims, and indeed one fellow saw a positive side to this situation, commenting that the fact that they did not have a room of their own meant that they met and got to know a far wider range of people than they might otherwise have done (including PhD students, final year undergraduates and post-doctoral researchers).

4.5.4 Are there any conditions for success?

In response to our enquiries at the end of the pilot year, one of the teacher fellows notes: ' *... it is hard to prescribe any particular formula that can guarantee success. It seems to me that the programme has been planned in a way that it promotes the greatest chance of success*'. Other comments, however, suggest that whilst nothing can guarantee positive results, there may be certain factors which help improve the odds of a fellowship being a success. The key factors are outlined below.

- **The outlook and culture of the host institution:** ideally the host university department will be forward thinking, open to change, and already committed to the review and refinement of teaching and learning activities. It will regard the teacher fellow as having valuable expertise and recognise this in a variety of ways, for example by allocating the fellow a formal position on the departmental teaching committee (or equivalent).
- **The personal and professional characteristics of the teacher fellow:** all the HEIs were very positive about their particular teaching fellow, but some comment that the scheme could have worked very differently (less successfully) with another individual. It was suggested that identifying the right individual, with the enthusiasm, energy and expertise to fulfil the brief, is critical, but might prove challenging. One academic respondent expressed the view that it is essential that departments are confident that candidates are not trying to 'escape' school; in contrast they need a clear commitment to, and passion for, teaching. The problem this presents is that these individuals are precisely the sort of teachers schools are likely to be most reluctant to release.
- **The planning of the placement:** the critical thing here is that placements are structured in such a way that they overtly minimise the disruption and maximise the return to the fellow's school. We were repeatedly told how important it was for schools to be given a full academic year to make arrangements for the fellow's absence. Prospective fellows and institutions also need to think about the geography of the placement – being close to home and school makes the placement more manageable for the fellow (in terms of both time and costs) and, critically, makes relationships with their school easier to sustain. This is significant in terms of both immediate and sustained (post-fellowship) benefits to the school: one fellow in this position comments how helpful it was that he could call in at the school from time to time and maintain a small number of responsibilities, for example analysing and preparing commentaries on examination results. This sort of activity will have had obvious benefits to the school but is also

likely to have benefits to the fellow as regards easing their return to normal duties at the end of the fellowship.

- **The utilisation of accumulated expertise:** one fellow commented how common '*reinventing the wheel*' is in teaching and several report having found the contact they have had with the very first (non-CFOF funded) teaching fellow and their contemporaries immensely helpful. The availability of opportunities to work with and learn from the other teacher fellows seems to have been an important ingredient in the success of the pilot programme. One fellow commented at the conclusion of the academic year that: '*a very strong aspect of the fellowship has been the networking with other school teaching fellows which we all hope to maintain*', whilst another reports that:

> *... the professional and personal relationships that have developed between the teacher fellows will be of great personal benefit to me in the future. It is inconceivable to imagine that we will not continue in our discussions and feedback about school-university transition.*

Several fellows appear to have taken steps to ensure that the learning that has taken place is not lost, for example, through the preparation of case study materials showing how a teacher can contribute to the university curriculum. In response to our end of year enquiries, one fellow told us that:

> *All of this year's teacher fellows are maintaining some contact with their host university and have indicated a desire to continue to communicate and work together. If this hadn't happened as a natural consequence of this year's work then I would have suggested that **some kind of formal mechanism to maintain the teacher fellow / university links as well as the links with the new cohort would have been a way to encourage sustainability and good practice**.*

4.6 Next steps: how might the scheme develop in the future?

A case was made by both fellows and academic hosts for the **extension of the fellowship from one to two years**, firstly on the grounds that this would allow fellows to see projects through to completion, and secondly to ensure the review and, if necessary, refinement of activities. One teaching fellow expressed very early on his desire:

> *... to see the process of lecture observation, feedback to teaching committees and modification to teaching go through a full cycle. This would involve an evaluation of any such changes. Evidently this could only be done in a second year.*

As there was no guarantee of funding for the post beyond the pilot year, one of the host institutions decided early on that the fellow's programme of work must focus on activities that could be sustained by core staff. In fact two of the full-time (fte) fellows will now be remaining in post until summer 2009; a third will continue in this role on a part-time basis (0.2 fte); and a fourth will retain an honorary status in the host department. **All departments were keen to maintain this type of role should continuation funding be available**. (At the time of data collection with the fellows and academics, continuation of funding had not yet been widely announced.)

However, whilst the merits of the scheme are thought sufficient to warrant the ongoing employment of a teacher fellow, it was also argued that where the placement is full time, **the secondment of any individual should be limited to two years**, on the grounds that: '*... any longer and the direct school experience of the [fellow] and his/her very grounded connections with the teaching community will become dulled*'.

One academic respondent questioned whether schools would be willing to release a member of staff for this length of time, and another felt that there would need to be flexibility in the scheme, to accommodate the differing needs, interests and circumstances of schools, fellows and departments. Our consideration of costs and benefits would suggest that **for the scheme to be fully successful, more attention will need to be given to limiting the negative impacts on schools, and ensuring those institutions releasing fellows both experience and recognise real benefits**.

In our most recent round of interviews, it is noted by several interviewees that the 'exchange' element of Strand 2 has not taken off. For example, an academic noted that '*it is regretful that more exchanges cannot be carried out in the reverse direction*'. A teacher fellow (from a different institution) commented on the satisfaction their academic colleagues appear to have derived from work with school-aged pupils, including those in the primary phase. **Developing more opportunities for academics (university staff) to work in or with schools** and their students might be one way of improving on the current balance of costs and benefits.

5. Strand 3.1: School-to-University Transition

This section presents an overview of the progress of Strand 3.1, the part of the Higher Education Curriculum Development strand that is focused on improving school-to-university transition. It includes findings related to strand management, progress made by projects, outcomes and impacts of their activities, and next steps. It is based on case study data, information provided by the projects and the RSC, as well as interviews with the strand coordinator at the RSC, and the Strand 3 leader.

5.1 Key findings

- The strand has been **effectively managed**, and a key success factor has been identification over time of the **most effective times and means to use to contact the project partners**.
- Almost all projects are **on target to achieve their aims**, and Strand 3.1 as a whole will be **delivered within budget**. However, **more lead-in time** for projects would reduce initial delays by ensuring staff are in place when projects start.
- Evidence suggests that school-to-university transition is being supported effectively, with **increases in attainment**, **improvements in the integration of first years**, and some evidence of **improved retention**. There is also evidence of lecturers' **greater understanding of the abilities/understanding of first year students**, and of resulting **changes to lectures and practicals**.
- Evidence suggests that these impacts can be achieved by providing **pre-induction materials, laboratory induction sessions**, early **opportunities for students to mix** and get to know each other, **support materials** alongside modules, and **interactive lectures tailored to the specific needs** of a student cohort.
- In 2008/09, the ten projects will be **building on the work** that they have completed in the first two years, whilst taking account of the lessons learnt so far (e.g. from student feedback). All projects will also continue to **evaluate** their work.

5.2 Introduction to Strand 3.1

This section presents an overview of the progress of Strand 3.1, the part of the Higher Education Curriculum Development strand that is focused on improving school-to-university transition. Together, the ten diverse projects that make up Strand 3.1 address the key areas of maths and practical skills, new teaching materials and student support schemes. The aims of Strand 3.1 are shown in the box below.

The aims of Strand 3.1 are to:

- develop first year undergraduate curricula that best support the school-to-university transition
- widen the uptake of chemistry by producing an attractive first year of study
- improve the retention, especially of widening participation students
- inspire new undergraduates.

The chapter builds on the findings presented in the interim report (NFER, 2008) by focusing on quantitative impact data and perceptions of impact at the end of the academic year in which the ten activities were run. The findings for this section are drawn from several sources of evidence:

- **case studies** of projects at Manchester, Hull, UWE and Southampton carried out in semester one 2007/8. Of the four case studies, those at UWE and Southampton are based on interviews with project staff and other staff in the department as well as focus groups with pupils; the Hull case study is based solely on an interview with the staff member leading the project; and the Manchester case study relies on student feedback both before and after the intervention
- **proformas** filled in by five of the ten project partners during summer 2008 (Loughborough, York, Bath, Southampton and Reading). These focused on gathering hard evidence of impacts arising from the projects (e.g. impact on attainment and retention). In addition, the project partner at UWE emailed information about the impacts of their activities in response to the proforma.
- **interim reports** sent by all projects to the RSC in January 2008, which covered progress, challenges faced, impacts of the activities and future plans
- a **monitoring report** sent from the RSC to HEFCE in September 2008, which covered progress to date of all projects
- **semi-structured interviews** with the strand coordinator at the RSC, and the Strand 3 leader. The interviews focused on progress made; strand management; what has worked well/not so well; outcomes and impacts arising from the activities; and plans for the extension year.

5.3 Strand management

Strand 3.1 is managed by the RSC, and overseen by the Strand 3 leader, the Dean of the Faculty of Natural Sciences at Keele University. In the set-up phase, the Strand 3 leader had a significant academic input to the project, handing over control to the RSC once the projects had been initiated. Members of the RSC Steering Committee and Project Advisory Group, the Strand 3 leader, and Project Officer at the RSC feel that Strand 3.1 management has been effective.

The Project Officer at the RSC administers the project and is responsible for funding and monitoring, acts as the point of contact for projects if they have any issues, and facilitates communication between project partners (for example, by organising meetings, putting individuals in touch if their work is related). A large part of the Project Officer's role at the RSC has been given to managing Strand 3.1, and this, along with the support and resources received from the rest of the team at the RSC, has been important to the success of the strand. He has been able to visit each project several times, and the detailed understanding gained has helped him facilitate links between partners both within the strand, and more widely in CFOF. A key learning point in terms of strand management has been the best times and means to use to contact the project partners, as they are often in laboratories doing research or teaching, and receive lots of emails.

5.4 Progress to date

In general, the projects are all on target to achieve their aims, and Strand 3.1 as a whole will be delivered within budget. Although they have not caused major problems, there have been two issues that impacted on progress in the earlier stages:

- **delays in recruiting** appropriate individuals to the projects. In addition, more lead-in time was needed to ensure that staff were in place when the projects were intended to start
- some projects that are more 'exploratory', and developing new activities, needed **reprofiling** of activities/timescales at the end of the first year, as it became clear that original plans were not realistic.

Data on progress to date has been taken from the RSC monitoring report to HEFCE in September 2008. The ten projects have all made progress, and have plans in place to build on their work in the extension phase. The progress to date of the ten projects is summarised in Table 5.1.

Table 5.1: Strand 3.1 projects and progress (September 2008)

University	Project Summary	Progress to date	Next steps
Bath	Developing contextualised online resources to cover essential mathematical principles for chemists.	VLE maths resources extensively developed and now in second year of trialling. Maths teaching website (www.symplekta.co.uk/QC) produced and feedback collated. Evaluation has advised Pfizer-funded *Discover Chemistry* maths initiative.	Further development of VLE resources. Continue evaluation of resources through interviews, case studies and feedback forms. Continue to contribute to Pfizer-funded *Discover Chemistry* maths initiative.
Bristol	Review of how maths is taught to undergraduates in UK HEIs, development of week-long maths workshop for 1st year undergraduate students without A-level maths.	30 HEI chemistry departments surveyed. Second week-long maths workshop conducted with students from around the country. Evaluation has advised Pfizer-funded *Discover Chemistry* maths initiative.	Complete survey of UK HEIs. Continue evaluation of workshop. Continue to contribute to Pfizer-funded *Discover Chemistry* maths initiative.
Hull	Two events for first years to improve team-working skills, build confidence and willingness to participate, one at the start of each semester.	Two events carried out for academic years 06–07 and 07–08. First event of academic year 08-9 conducted. Evaluation of impact conducted over two-year period.	Continue evaluation. Continue to modify and improve events in light of feedback. Promote sharing of good practice through Hull website.
L'boro	Reviewing first-year teaching and introducing concepts in a logical order to mesh with A-level knowledge of students.	Reviews completed of A-level and Loughborough level-one curriculum. Thorough evaluation of perceptions of undergraduates completed. 'Concept Map' created.	Continue to review perceptions of undergraduates and A-level/1st year curricula. Develop proposal for implementation of concept chain into 1st year course.
Manchester	Improving undergraduate practical skills through a week-long residential pre-induction course.	Thorough evaluation of impact of '07 boot-camp conducted. Feedback incorporated into '08 boot-camp. '08 boot-camp conducted during August '08.	Continue evaluation of impact on student uptake, performance and retention. Develop content and design of boot-camp for 2009.
Reading	Supporting new students through directed self-study, a parenting scheme and non-traditional course delivery using a Personal Response System (PRS).	Online self-study materials improved. Use of PRS handsets extended into new modules for 2008-9. Mentors to receive credits for 2008-9. Improvements made to 4-week introductory practical course. Evaluation of impact conducted. Extensive	Continue to develop online self-assessment. Extend use of PRS in lectures. Improve practical skills course. Roll out problem-solving to other modules. Continue to work with

		collaboration with Southampton.	Southampton.
S'oton	Support and extend current activities to support students through: pre-induction activities, resources to bridge the knowledge gap between school and university, and activities to motivate and integrate students.	Promoted use of Personal Response Systems (PRS) in lectures. Further improved student 'welcome' website. Conducted additional induction activities. Improved online learning resources. Extensive collaboration with Southampton as well as RSC teacher fellows including development of the Interactive Lab Primer (ILP) http://www.rsc-teacher-fellows.net/.	Continue to develop and embed activities and resources into the first year curriculum. Continue research into the use of PRS in lectures and extend their use into new areas of teaching. Continue to work with Reading.
UWE	Address the pre-arrival knowledge gap in chemistry using short, online video clips focused on 'bite-sized' learning objectives	40 organic chemistry videos now produced for open-source VLE (http://science.uwe.ac.uk/ls/orgchem/). Training day on how to use Camtasia software scheduled. Sharing of knowledge with other project partners. Evaluation of impact conducted.	Continue to develop organic chemistry videos for VLE. Build in more self assessment questions. Deliver Camtasia workshop. Continue evaluation.
Warwick	Qualitative and quantitative impact analysis of the Science for the 21st Century initiative.	On-going evaluation of the initiative being conducted. Research training programmes for students run in clusters around Warwick and Cambridge. Planning and preparation for Showcase Science 2009 is well underway.	Continue to develop the school/university-based research training programme. Deliver Showcase Science 2009. Continue evaluation of the project.
York	Develop a support network that will coordinate academic, pastoral and social aspects of level-one chemistry, and establish school outreach by first year undergraduates.	Schools outreach visits by first years and student mentor scheme continued. Links with ChemSoc have been strengthened. Revision workshops built into mentoring scheme. Impact measured through evaluation questionnaires and tracking student attendance, performance and feedback.	Continue to recruit student mentors and deliver outreach to schools. Continue to develop mentoring scheme and student support network. Continue to evaluate impact.

5.5 Outcomes and impacts

The evidence collected to date suggests that the activities are having a significant impact on students and on universities. The main impacts are on student attainment, student transition to university, and on chemistry teaching.

Students and their lecturers feel that **attainment** has been improved through the provision of:

- access to **resources to fill gaps in their knowledge** from A-level, and to **revise topics or areas** that they are struggling with

- teaching directed at their specific needs (e.g. utilising PRS)
- **improved practical skills** from laboratory inductions or pre-induction courses.

There is hard evidence that suggests that such activities and resources have helped improve the attainment of first year students, as marks have improved in modules now supported by CFOF activities when compared to marks from previous cohorts. Examples of such evidence are included in the box below.

Examples of improved attainment

- At UWE, activities included provision of chemistry videos and optional support classes to sit alongside an organic chemistry module. The pass rate rose to 70 per cent in 2007/8 from 64 per cent the previous year.
- At Bath, the mathematics unit for chemists is now supported by online resources that set the mathematics problems in a chemistry context, and the pass rate has increased to 64 per cent from 47 per cent in 2006/7 and 50 per cent in 2005/6. The number of students failing in 2007/8 was only two out of 24, whereas in the past between eight and ten would generally fail.
- Following an introductory practical course for first year students at Southampton, the average mark for subsequent practical modules was 64 per cent, compared to a 2006/7 average of 54 per cent, and a 2005/6 average of 58 per cent.
- The twelve students who participated in a pre-induction week-long practical skills course at Manchester university scored on average nine percentage points higher than the rest of their cohort (224 students) in the two first semester practical modules.
- At Southampton, higher marks were achieved in the inorganic chemistry exam, which was supported by PRS use in lectures.
- Average marks in modules where PRS was used at Reading were higher than previous years, despite results for other modules being slightly lower. Focusing on the exam questions in the specific areas where PRS and online tests were used, the 2007/8 average was 63 per cent, compared to 51 per cent in 2006/7, and 46 per cent in 2005/6.

In general, project staff feel that their activities have improved the integration of first year students into their departments to some extent and have enabled them to make a more successful **transition** from school to university. The project manager at the RSC feels this is due to the increase in resources and support targeted at first years, and the increased engagement between teachers and lecturers facilitated by the projects. Examples of such evidence are included in the box below.

Examples of improved transition

- There is some evidence from Southampton and Bath that **retention** has been improved during the first year, although project staff are cautious about attributing this to their projects. In 2007/8, Reading took on a larger number of students than normal through clearing, and therefore the prior experience and standard of incoming students was more diverse than in previous years. It may therefore have been reasonable to expect that retention would decrease, but it remained the same as the previous year.
- The mentoring programme at York substantially increased first year students' **links with those in higher years** (44 per cent felt they had 'adequate' or better links, compared with 24 per cent in 2006/7). The programme also increased students' knowledge of the **exam format, exam procedures and year two options** (an average increase of 16 percentage points of those saying they had 'enough' or more knowledge over the previous year)
- Students who experienced **pre-induction materials and courses** felt that this helped them settle in to university life. For example, following a pre-induction practical skills course, one student explained: '*I feel settled in before I even start and made some great friends along the way*'.
- Students also felt more confident about starting their course when they knew there were **support materials available if they had difficulties** with any parts of their studies. As one student commented regarding the videos supporting an organic chemistry module: '*It makes it seem more possible, that you can really do it if you put some effort in and watch the videos … you might pass it after all!*'

The activities have also had some impacts on **chemistry teaching** in departments. **All project partners who returned a proforma** to the NFER evaluators noted that their Strand 3.1 activities had **increased their understanding of the school curriculum and associated teaching practices**, and **most** made clear that they had a **greater understanding of the abilities of their undergraduate students**. As a result, all had also made changes to **the way teaching is delivered** to students in lectures or practicals. Staff at two universities using PRS in lectures (Southampton, Reading) explained that as the benefits of the system are seen, more staff are interested in using them as part of their teaching. One lecturer explained the benefits of PRS that he had discovered: '*It allows you to find out what* [students] *do know and what they don't know instantaneously so as you go through the session you can cover points in more detail that they are struggling on…*'. The project manager at the

RSC feels that the spreading of new teaching methods both within and beyond chemistry departments is a key impact arising from Strand 3.1.

A final impact has been on **participation in the chemistry societies** at York and Hull, where they play an integral part in the activities. For example, average attendance in the first semester at ChemSoc in Hull doubled from around 12 to around 25 students.

Overall then, the evidence suggests that the strand is beginning to be successful in meeting its aims. The first year curricula and activities developed through the project are supporting school-to-university transition, for example as seen through the increases in attainment and integration of first years. There is some evidence that retention has improved generally, although not relating to widening participation students specifically. There is no specific evidence yet that undergraduates are being inspired or that the uptake of chemistry is being widened. However, if attainment, retention and integration of first years are being positively impacted by the activities, there is the potential for undergraduates to be more positive about the subject, and for there to be a 'trickle-down' effect which could encourage more individuals to study chemistry at university.

5.6 What works and lessons learnt

Lessons learnt from activities to date are that the following can have a positive impact on school-to-university transition:

- making sure that there is the right balance between supporting students and encouraging their independence
- providing **pre-induction materials** (for example, example timetables, virtual tours of the department, revision materials)
- delivering laboratory induction sessions to students and giving opportunities for them to mix and get to know each other soon after they have arrived
- ensuring that there are **support materials** available that students can use if they are struggling with their course. An effective example is **chemistry support videos** delivered online**,** encompassing teaching material and opportunities to test knowledge
- **directing lectures and revision at the specific needs of students**, and ensuring that lectures are **interactive and engaging** (for example, using

Personal Response Systems to test how well students have understood concepts, and to keep students engaged).

Challenges identified by university staff include persuading other staff to support and use new ways of teaching undergraduates, ensuring that study support resources are widely advertised, and that activities do not take time from other lectures/practicals, or clash with other events (e.g. in freshers' week).

The boxes below provide some examples from our case-study data. The case studies focus on the activities undertaken, what worked well, and the perceived impacts when the research was undertaken (semester one 2007/08).

Case Study UWE: Video support resources

Activity

Short online chemistry videos with self assessment questions were developed to support students without A-level chemistry who had core chemistry modules as part of their course. These were used alongside support sessions for the targeted students.

What worked well?

Students were very positive about the videos, appreciating the extra support available to them, and feeling that the videos were an effective way for them to learn, revise, get to grips with topics they were struggling with, and check their understanding via the self-assessment questions. The videos were good as students could watch them repeatedly, use them whenever they wanted, pause them at intervals if the pace was too much, or go back to a specific segment that they were struggling with rather than watch it all again. They also felt that the mix of audio and visual presentation made it easier to take the information in. Some students felt that the videos were as good, or better, than going to a support lecture on the same topic.

Impacts

- It was felt that the videos:
- Eased the transition to university as students were aware that there was support available in the areas they were struggling
- Impacted positively on academic achievement as students learning and revision was supported
- Increased retention as students felt they would have struggled to cope with the course without the resources.

Case Study Hull: Inspirational activities for first years

Activity

There were two new activities devised and run for first year chemistry students by Chemsoc and the department. The first, held at the start of semester one, aimed to facilitate students getting to know each other and the staff through group work activities, games and quizzes in a relaxed environment. The second, held at the start of the second semester, aimed to re-enthuse students after their exams, to think creatively about how their chemistry knowledge can be applied, and to start to build important generic skills (e.g. team working, presentation skills).

What worked well?

Students enjoyed the events, and the first session was effective in facilitating students to get to know each other and other members of the department.

Impacts

It was suggested that the impacts from the second semester were unclear as yet, and would be more apparent in the longer term as students have to apply their knowledge more later in the degree. However the impacts from the first semester session were that:

- Students know each other more than they did before the sessions were introduced, and the staff expect this to help retention in the first semester.
- Membership of Chemsoc has risen, and attendance at events has doubled.

Case Study Manchester: Pre-Induction Practical Skills Course

Activity

A five day practical skills course in the summer for 22 students who were about to start chemistry degrees at various universities. During the week there were four experiments to complete, and on the final day the students wrote up laboratory reports, which were marked whilst they watched a ‘flash bang’ chemistry demonstration, and then comments fed back to students.

What worked well?

Students were very positive about the course and had enjoyed it, feeling that the staff and demonstrators had been very friendly and helpful, and they appreciated the opportunity to improve their practical skills in a university laboratory and brush up on their chemistry knowledge before their courses started.

Impacts

The students identified several impacts of the course:

- They were more confident that they could successfully perform practical experiments at university.

- They had improved their practical skills and theoretical chemistry knowledge
- They felt more confident that they would be able to successfully study chemistry at university, were satisfied that they had made the right choice, and were looking forward to the start of their courses.

Case Study Southampton: Support from registration to graduation

Activity

The package of activities aimed to support students from the pre-induction stage (via a welcome website), through an improved induction process (e.g. including a laboratory induction), and improved teaching and learning via the use of ‘who wants to be a millionaire’ style handsets (e.g. to assess students knowledge by test questions in lectures), by reviewing the A-level curriculum to assess what students would know on arrival, and providing e-learning materials to support learning.

What worked well?

All of the activities had generally worked well. In particular the **welcome website** was appreciated by students as it told them what to expect from the course from a student perspective, provided revision and study materials to revise or fill gaps in their knowledge, and it gave them a contact in the department if they had any worries or queries. Students also found the **laboratory induction** session useful as they got to know other students in their group, the laboratory staff and the layout and scale of the laboratories in an informal way, before they had to go in and start working. Students and staff were positive about the **handsets in lectures** because their use made lectures more interactive, and because they showed students and lecturers exactly what the students did and did not understand, enabling lectures and revision to be targeted at weak areas.

Impacts

There were two main areas of perceived impact from the project as a whole:

- Academic improvements from using the handsets as students got immediate feedback about what they did and didn’t understand, and lecturers could take account of this in their teaching, as well as from having the e-learning support materials.
- An improved transition to university as students were more confident about starting, about working in the laboratories, and about their own knowledge, as they were getting immediate feedback that told them when they didn’t understand.

5.7 Additionality

The evidence suggests that Strand 3.1 activities would not necessarily have happened without the CFOF funding, and that additional benefits have been gained through adopting a partnership approach for the benefit of chemistry, rather than individual institutions. These additional benefits are:

- **creation of a group focused on school-to-university transition**, which acts as a forum for discussing issues and sharing best practice
- **sharing between universities,** for example of technologies and teaching and learning materials.

The Strand 3 leader feels that Strand 3.1 represents the best value for money of all four elements of Strand 3, and that although the activities do not necessarily make up a large element of the degree course, they do have a significant impact on students. In addition, there have been some overlaps between Strand 3.1 and Strand 2, which have had added benefits in the form of greater understanding between teacher fellows and academics in terms of school-to-university transitions.

5.8 Next steps

The ten projects all have definite plans for the extension phase, and will be focused on building on the work that they have completed in the first two years, whilst taking account of the lessons learnt so far (for example, from student feedback), and updating/improving resources and activities based on those lessons. For some projects this will mean developing new activities/resources, whilst for others it will mean further refinement and development of existing activities/resources.

6. Strand 3.2: Chemistry for All

This chapter explores the progress of Strand 3.2 of CFOF which focuses on delivering context- and problem-based learning (CBL/PBL) materials within chemistry courses at four UK institutions. These are the University of Leicester, Nottingham Trent University, the University of Plymouth and the University of Hull. CBL/PBL materials are being used within both case study investigation and laboratory work and are being used with a range of students including those studying both full- and part-time. The four project partners have been involved in both experimenting with delivery and evaluating the effectiveness and outcomes and impacts of their activities.

The chapter draws on data collected by NFER at Strand 3 and project partner meetings, telephone interviews with project partners and the project coordinator, and evaluation reports and papers submitted by project partners.

6.1 Key findings

- The four project partners have all made **good progress in line with their initial aims and objectives** and have, in general, completed all of the activities planned within the timescales set.
- **CBL/PBL has been shown to be a very effective method of teaching via both case study investigation and in laboratory work.** It enables and encourages students to work together in groups and to learn from each other. Students engage with the investigative approach and with sessions in which chemistry is applied to real world situations.
- However, **a range of challenges can be faced in introducing CBL/PBL** in institutions new to the approach. These include: gaining the wider interest and enthusiasm of academic staff and the lack of instrumentation and suitable accommodation. It is also important to note **that time and skill is needed to both write and deliver successful CBL/PBL materials** and to ensure that student learning is not superficial.
- There is also a **need to invest time up-front** to counsel students about the teaching and assessment methods to be used and to explain how they differ to approaches they are more familiar with. Students also need to be provided with **on-going support and guidance**, at least in the early stages.
- In terms of soft outcomes, **students gain a range of skills** from their involvement in CBL/PBL sessions. These include: the development of group work skills and other transferable skills such as: communication, presentation skills, task and time management, problem solving and critical thinking and report writing. Through the group work, students can

also develop **strong friendships which help them settle into university** life. Another key outcome is the **increased employability** of students through their understanding of the application of chemistry in the real world.

- **Staff benefit from the approach in terms of increased interest, confidence and skills in using CBL/PBL** approaches and a greater understanding as to how students work, which can help in terms of supporting students more effectively and providing better feedback on their progress.
- For the institutions involved in this strand, a key benefit has been increased partnership working and **the sharing of knowledge and experience**.
- The evidence collected by the project partners suggests that **using CBL/PBL does not impact significantly either in a positive or negative way on student attainment. This is encouraging considering the range of important skills that students develop during the process.** Where the assessment procedure is familiar to students i.e. there is a correct answer, they are likely to do as well as in other more traditional modes of assessment. Where assessment criteria is more open ended and there may not be a right answer and where, for example, students are required to discuss their reasons for their decisions and actions, demonstrate a sensible rationale for the methodology and evaluate the effectiveness of the group work, performance can be lower than in other types of assessment, such as laboratory reports, even if the subject matter is similar. However, once students become more familiar with this new approach, attainment is likely to rise and be consistent with that of other forms of assessment.
- In relation to next steps, Leicester and Nottingham Trent plan to embed CBL/PBL across the three year chemistry curriculum. Plymouth plan to develop more laboratory based materials and Hull propose to internationalise their existing case studies. Evaluation work will also continue as planned.

6.2 Introduction to Strand 3.2

The project partners in Strand 3.2 are the University of Hull, the University of Leicester, Nottingham Trent University and the University of Plymouth and the focus of projects is on providing a data set for evaluating the effectiveness of context-based learning (CBL) and problem-based learning (PBL) approaches in modern university chemistry curricula. The aims and objectives of the strand are shown in the box below.

The aims of Strand 3.2 are to:

- implement existing CBL/PBL materials into undergraduate chemistry courses
- measure the effects of these alternative approaches with different student groups (e.g. part-time, distance learners, different stages, foundation courses) in terms of student performance, student satisfaction and engagement, staff perceptions and resource implications
- investigate the transferability of existing CBL/PBL materials to institutions other than those where they were initially developed
- explore existing and/or related CBL/PBL materials that are being used in other institutions
- share good practice, ideas, materials and innovation and provide rational cross-discipline planning in collaboration with the parallel HEFCE funded Institute of Physics project – 'Stimulating Physics'
- identify areas for future development
- develop some new materials tailored for the delivery of CBL/PBL approaches.

With the changing student population and the widening participation agenda, in addition to the focus of many A-level courses on the learning and regurgitation of factual information in an exam-driven environment, there is now a real need to engage students' interest in chemistry as a subject and to increase their interest and understanding. CBL/PBL approaches are an important way of achieving this engagement and of helping students to understand why they need to know and understand concepts and factual information. However, it is important to note that CBL/PBL approaches complement rather than replace other more traditional approaches to teaching and learning.

The underlying pedagogic philosophy of CBL/PBL is that students learn both the principles and applications of a topic by tackling problems related to it. CBL/PBL aims to stimulate students to learn by presenting them with a real life problem to solve. In solving the problem, which is usually done in small groups, they use previously acquired knowledge, whilst also acquiring new knowledge and learning new skills. CBL/PBL encourages students to use knowledge gained from learning in other modules and to understand the links between different knowledge areas which helps them in the exam situation and in the world of work.

This report of progress for Strand 3.2 draws on data collected by the NFER at a meeting of Strand 3 deliverers held on 29th November 2007, a meeting of project partners held on 18th December 2007, telephone interviews with project partners and the project coordinator conducted in November 2007 and June/July 2008, attendance at the CFOF 2nd National Conference held in July 2008 and reports and evaluation data provided by projects. This includes an initial evaluation report written by the external evaluator working on the project and a paper written by the project partner at the University of Plymouth.

6.3 Strand management

Strand 3.2 has been coordinated by a project coordinator, based at the University of Leicester, who was appointed in April 2007. The coordinator has been responsible for coordinating the work of all four project partners and was employed on a part-time basis for the CFOF Strand 3.2 project and was also employed part-time on the parallel HEFCE ‘Stimulating Physics’ project. This allowed for the sharing of information and good practice across the chemistry and physics projects.

The funding allocated to Strand 3.2 was £280,000 and all of the funding, except £60,000, was allocated equally (£55,000 each) to the four partner institutions with the project coordinator at Leicester receiving £35,000 for her part-time role. The remaining £25,000 was used to support partnership working and the development and dissemination of resources.

Project partners feel that the strand has generally been well managed and that partners have a clear idea as to what they want to do with the funding and have undertaken what they intended to do within the timescales agreed. Partners have also met regularly to share information and practice. There were, however, some changes of staff in 2008 within Nottingham Trent University and the University of Leicester. The project officer employed at Nottingham Trent University, who was responsible for developing, implementing and evaluating CBL/PBL materials, left in December 2007 and a replacement did not start until April 2008, resulting in a three month activity gap. At Leicester, the project lead left early in 2008 and the project coordinator left in July 2008. The coordinator has now been replaced, with a full-time appointment to the role, to facilitate CBL/PBL. These changes of staff have impacted to a small extent on what has been achieved.

6.4 Progress to date

All of the four universities involved in delivering CBL/PBL activities within Strand 3.2 have a different focus to their work:

- the Universities of Hull and Plymouth have been delivering courses using CBL/PBL approaches for several years and the focus of their work has primarily been on evaluating the impacts of the CBL/PBL approach on both students and staff
- Nottingham Trent University have used existing ideas and scenarios from other institutions and have delivered them to their own students with the aim of assessing the transferability of materials developed elsewhere. They have also developed some materials from scratch. In addition, a survey of the content of chemistry degrees in England has been undertaken and the findings will be used to complete a review of the CBL/PBL material existing in chemistry
- the University of Leicester have developed their own materials from scratch and have also drawn on ideas and approaches from elsewhere. They have transplanted a large proportion of CBL/PBL content into existing modules for first year students. The impact of this approach on staff, students and the chemistry department has been evaluated on an on-going basis.

All of the partners have, in general, successfully met their initial aims and have delivered all of the activities that were intended. As mentioned above, the loss of a staff member at Nottingham Trent has had a small impact on the evaluation of what has been achieved there.

Across the project partners, the CBL/PBL approach to teaching and learning is being used with students on a range of courses and at different stages within their course (i.e. from first to third year students). Students targeted include: chemistry degree students, foundation year chemistry students, forensic science degree students, environmental science degree students and pharmaceutical science degree students. CBL/PBL is being used with both full-time and part-time chemistry students. The CBL/PBL approach is being widely used within case study investigations and, to a lesser extent, within laboratory work, though this is a developing area. Partners have collected statistical and qualitative data to assess the outcomes and impacts of CBL/PBL on students and staff and, brought together, this provides a good insight into the successes, challenges, outcomes and impacts of this approach.

Project partners have been working together effectively to share good practice and learning. This has included a range of dissemination activities to more widely publicise the approach.

More detail on the activities of each of the project partners and the key findings of their evaluation activities to date is provided in Table 6.1 below.

Table 6.1: Strand 3.2 projects and progress (September 2008)

University	Project aim	Progress to date	Key findings of evaluation activities
Leicester	• To develop CBL/PBL materials from scratch and draw on ideas and approaches from elsewhere and evaluate impacts.	**CBL/PBL in chemistry degree** • CBL/PBL has been introduced into the core physical and inorganic module (CH1000) in the first year chemistry degree. 84 students started this degree in the 2007/8 academic year. 2 CBL/PBL sessions were delivered a week and students' CBL/PBL work contributed 15% to the 20 credit module. Also new has been the delivery of sessions using a Wiki (an editable web page). **CBL/PBL in chemistry foundation year** • CBL/PBL has been introduced into the second semester of the foundation year of a four year BSc in chemistry (19 students started in 2007/8) from which students continue onto the three year chemistry degree course. The CBL/PBL approach is primarily being used in teaching physical and inorganic chemistry topics such as thermodynamics, energy, stoichiometry and kinetics. Students have received a one hour introduction to the topic to be studied and have then worked in groups with support from a staff member facilitator for two additional one hour sessions. **Dissemination activities** • In conjunction with representatives from the Universities of Hull and Plymouth, a representative from Leicester presented at a Science teaching and learning event in Leicester. This staff member also ran workshops at the HEA Subject Centre for	**CBL/PBL in chemistry degree** • Overall, the CBL/PBL approach has neither had a positive or negative impact on the attainment of first year chemistry degree students. It is, therefore, considered as a success. Exam based assessment can often lead to higher marks with students trained to pass the exam but it does not necessarily produce students who are able to think for themselves, and who can use materials from other modules, and who will have the skills required to succeed in employment. • Feedback from staff and students focuses on two main positive themes: increased student motivation through the use of real world scenarios (which has positively impacted on the learning process) and the gains that are realised for student through the group work which include new friendships and increased retention. 89% of 2007/8 students progressed into year two as opposed to 83% in 2006/7, when CBL/PBL was not used. • Some students have commented on problems faced when groups do not 'gel' and staff feedback suggests that delivering CBL/PBL has been staff intensive, particularly in terms of its use of postgraduate students. Finding suitable accommodation for the group work has also been challenging at times. **CBL/PBL in chemistry foundation year** • The feedback from students undertaking the foundation year has been generally good with the majority recognising the benefits of the approach which makes them think in a different way and involves applying material covered in previous modules. Other benefits

		Physical Sciences Special Interest Group. In addition, Leicester representatives have presented at the sixth annual summer PBL workshop held at Leicester and at the Variety in Chemistry meeting this year in Dublin.	relate to the development of friendships through the group work and the development of transferable skills such as communication and planning. • The 2007/8 retention rate was 90% which suggests high satisfaction. **Staff feedback** • Staff commitment to CBL/PBL has grown over the course of the project and CBL/PBL is now being taken forward by teams rather than individuals due to a shift in attitudes. Staff not involved in CBL/PBL have benefited from students being more confident in working together and interacting with staff.
Nottingham Trent	• To deliver existing ideas and scenarios from other institutions to assess transferability as well as developing materials from scratch. • To survey the content of English chemistry degrees. • To review the CBL/PBL content of chemistry degrees	**CBL/PBL within laboratory work** • A set of existing practicals from elsewhere have been contextualised by modifying existing physical chemistry laboratory classes into CBL/PBL scripts. These scripts have been used with one group of first year forensic science students (15 students). • Laboratory scripts for year two inorganic laboratory classes have been developed and delivered in term two of the chemistry degree (two groups of students, a total of 45). A suite of four inorganic experiments have been created as part of the second year 'circus' of experiments. These are CBL/PBL modifications of typical inorganic practicals. These practicals have run alongside procedures with a more traditional approach, which has allowed comparisons to be made. **CBL/PBL within tutorial support** • A tutorial pack for organic chemistry has been developed using newly created CBL/PBL resources, that link in with difficult concepts from lectures, with the aim of increasing students'	**CBL/PBL within laboratory work** • Students have found the 'new' contextualised physical chemistry laboratory scripts more interesting/engaging than previous experiences. The CBL/PBL supervisor/technician helped students with difficulties and recognised that students differ in their needs, concerns and interests and need individualised support. **CBL/PBL within tutorial support** • How the CBL/PBL tutorial packs and resources have been received and their benefits are currently being evaluated. **CBL/PBL within case study investigation** • Students had not been exposed to this type of work/assessment before and were, as a result, a little unsure initially as to how to apply themselves to the task required which resulted in staff spending more time with students in the introductory sessions providing them with information and guidance. However, data from the module feedback forms suggests that students really enjoy and engage with this aspect of the course and would welcome more sessions delivered using the CBL/PBL approach.

		understanding. These packs were distributed to all year one students on the chemistry programme (55 students) throughout term one as tutor groups rotated between physical, inorganic and organic chemistry. • CBL/PBL resources have also been incorporated into chemistry tutorials for year one forensic science students (12 students). Standard paper-based materials have also been used for comparative purposes. **CBL/PBL within case study investigation** • 'On the River Bank', developed by the Universities of Plymouth and Hull, has been delivered to year three students on the environmental science degree (there are 10-15 students per year on this course). **Review of CBL/PBL materials within chemistry** • This work is in its early stages. Questions on CBL/PBL materials have been included in the national surveys of the *Student Learning Experience* for chemistry and physics, which have been undertaken by the HEA Physical Sciences Subject Centre during 2007/8. In collaboration with the HEA Physical Sciences Subject Centre, Nottingham Trent have collected the data. This is being followed up by a more detailed study which is currently underway. **Survey work and dissemination work** • A curriculum survey of the content of undergraduate chemistry degrees across England has been undertaken. Findings have been compared with those of a smaller survey of first year chemistry undertaken in 1998.	• Feedback from staff suggests that introducing CBL/PBL sessions developed elsewhere works well when they are well constructed and provide enough detail for both the student and teacher, as was the case with this particular case study. **General findings regarding implementing CBL/PBL** • In general, the learning from the range of activities delivered at Nottingham Trent has been around change management and how to ensure that staff have the necessary confidence, in addition to time, resources and support, to develop and deliver CBL/PBL sessions. • Difficulties have been faced in implementing new laboratory-based CBL/PBL where technicians have been very familiar with older experiments. In addition, the availability of instrumentation and chemicals has sometimes been an issue. **Survey work** • Important new topics which have been introduced to chemistry syllabi in recent years include those in the typical 'buzz areas' such as nanotechnology, modelling & simulation.

		• A paper outlining the findings of the survey - *The Shape of Chemistry in 2008* - was presented at the Variety in Chemistry Education (ViCE) 2008 conference attended by approximately 200 delegates. Current collaboration with the *Education in Chemistry* Journal means that the full survey will be published. An *opinion* piece is also being prepared for the journal *Chemistry World*.	
Plymouth	• Plymouth have been delivering courses using CBL/PBL approaches for several years and the focus of their work has primarily been on evaluating the impacts of the approach.	**CBL/PBL within case study investigation** • Plymouth have been using the case study approach in the teaching of analytical chemistry since 2001/2 across all chemistry degree year groups. This has included the following case studies delivered to year two students: ➢ 'The Titan Project', which is a case study that requires students to research two different manufacturing processes for the industrial scale production of Ti02 ➢ 'New Drugs for Old', which involves devising short- and long-term investigations of a potentially new analgesic drug isolated from a natural source ➢ 'Tales of the Riverbank', which requires students to consider some basic principles of analytical measurements within the applied context of pollutant species within a river system. • In addition, over the past seven years, 'The Pale Horse' case study has been used as part of an approach to the teaching of analytical chemistry to year three students. **CBL/PBL within laboratory work** • Plymouth have used CFOF funding to further develop the usage of CBL/PBL in laboratory work. This includes the development and piloting of new	**CBL/PBL within case study investigation** • The key finding from Plymouth's analysis of student assessment and performance data for case study activities over the past seven years is that, if you assess CBL/PBL using assessment procedures and criteria which are familiar to students (as is the case for year two CBL/PBL case studies), then they do as well as in other more traditional methods of teaching and learning within the same module. Although they may be unfamiliar with the contextual and, in some cases, open-ended nature of the problems within the case studies, they still do well if they are familiar with the assessment methods i.e. if a high proportion of marks are allocated to students achieving the required solution. However, where assessment criteria is more open ended and, for example, includes students discussing reasons for decisions and actions, having a sensible rationale for the methodology and evaluating how the group worked – which has been the case within year three assessments – performance tends to be lower than in other types of assessment, such as laboratory reports, even if the subject matter is similar. • Feedback from students in relation to CBL/PBL suggests that they find sessions motivating and enjoyable, yet frustrating and demanding initially. Over time, they appreciate the fact that they are learning chemistry in a real world context and are developing a range of key

		organic chemistry laboratory materials for year one students. Students have also carried out more traditional, prescriptive style laboratory investigations which has enabled the two approaches to be compared. • Plymouth have also piloted materials for an additional case study for use with first year students in the second term. This case study, which was delivered in 2007/8, is a four week investigation into the possible contamination of chewing gum. **Dissemination activities** • With other project partners (Leicester and Hull), Plymouth staff have been involved in a variety of dissemination events including presenting at a Science teaching and learning event at Leicester and to the HEA Subject Centre for Physical Sciences Special Interest Group. A total of 100 delegates attended these workshops and the second workshop was attended by academics from around the country. In addition, Plymouth have run workshops with local school teachers (focusing on laboratory work) and at the Variety in Chemistry meeting in August 2008 in Dublin.	skills, including group work, time management and presentation skills, in particular, which will increase their employability. **CBL/PBL within laboratory work** • An analysis of student marks, comparing marks for traditional/prescriptive laboratories with CBL/PBL laboratories, shows that marks tend to be slightly lower for CBL/PBL laboratories. • Pre-laboratory exercises have been shown to be particularly important and effective for CBL/PBL laboratories since they are key to preparing students for the CBL/PBL approach to the subject. • Students appear positive about CBL/PBL laboratories and appreciate what they learn from them, including enhancing their knowledge through group work and contributing to the experimental design which improves knowledge of the theory and their understanding of the practical work. However, the findings also show that students like the security of working to an agreed procedure.
Hull	Hull have been delivering courses using CBL/PBL approaches since the late 1990s and the focus of their work has primarily been on evaluating the impacts of the approach.	**CBL/PBL within case study investigation** • Hull have delivered the following CBL/PBL case studies since the late 1990s: • Chemistry foundation year: 'The Pale Horse' (forensic analysis) and 'New Drugs for Old' • Year 1: 'The Titan Project' (full-time chemistry students); and 'New Drugs for Old' (full-time pharmaceutical science students); 'Between a Rock and a Hard Place' and 'Chemistry in Sport'	**CBL/PBL within case study investigation** • Students have been very positive about CBL/PBL and perceive it to be a more interesting and enjoyable approach to learning than more traditional approaches (such as lectures and tutorials). Staff have found the approach more enjoyable to teach since it allows more interaction with students and enables them to give more informed feedback. • Feedback from staff and students suggests that students benefit from the CBL/PBL case study approach in terms

		(part-time chemistry students) • Year 2: 'The Pale Horse'(full-time and part-time chemistry students); 'Chemistry in Sport' and 'Between a Rock and a Hard Place' (part-time chemistry students) • Year 3: 'The Pale Horse' (full-time chemistry students). **Dissemination activities** • Hull have been involved in a range of dissemination activities which are mentioned above in the Leicester and Plymouth sections.	of: ➢ the development and application of skills with presentation, communication, group/team work, problem solving, decision making, time management, analytical methods and techniques, independent learning and research skills being identified, amongst others ➢ the more active engagement of students, with more interaction and involvement with the subject matter as well as with the tutor and one another ➢ the opportunity to apply new and existing knowledge ➢ working with real world scenarios ➢ working in a team/group which leads to greater retention of the subject matter as well as the acceptance, verification and reinforcement of ideas. • Students perceive the disadvantages of this type of learning over traditional lectures to relate to the lack of guidance from tutors regarding the learning material (students are sometimes worried that they are not covering the right ground) as well as doubts/worries about the amount they are expected to learn and deadlines. Group dynamics are also a concern, particularly in relation to students in groups who do not contribute. In addition, part-time students studying remotely need more support, particularly in the early stages. • The key disadvantages staff have cited relate to the increased time commitment, as students have to be split into smaller groups, and the fact that some students do not take the CBL/PBL approach seriously because it is not assessed by a final examination. Additionally, they have commented that, although most students enjoy the approach, some worry about 'coverage'.

More detail on the progress of each Strand 3.2 partner institution, including activities undertaken and outcomes and impacts realised, is provided in Appendix C.

6.5 What works well and lessons learnt

This section aims to draw together information from across all of the project partners in relation to what works well and the lessons learnt from implementing CBL/PBL. It is worth noting that some of the CBL/PBL materials that have been developed and adapted by Strand 3.2 partners have been put on the Physical Sciences Centre part of the Higher Education Academy (HEA) website so that they are widely available to other institutions. They can be found under the PBL pedagogic theme and, within that, in the section for the Context and Problem Based Learning SIG (Special Interest Group) http://www.heacademy.ac.uk/physsci/home/networking/sig/CPBL

What works well?

The evaluation data shows that the CBL/PBL approach can be **effectively used via case study investigation and within laboratory work**. The advice is that a 'blended approach', in which CBL/PBL is combined with more traditional approaches, is more successful than 'pure' CBL/PBL. Where CBL/PBL is used in laboratory work, **pre-laboratory work is effective** in preparing students for the laboratory work and making a more dynamic laboratory session. When CBL/PBL is being used via a case study approach, it works well when topics and information is presented in lectures prior to CBL/PBL activities being initiated and where there is continuity between sessions. CBL/PBL works well when staff retain some **flexibility in delivery**, responding to students' needs and the direction they are pursuing. The **use of postgraduate students is effective** in supporting the sessions; the CBL/PBL approach requires that students are provided with more on-going support than more traditional approaches to teaching and learning.

Students do well when they have a good understanding as to how they will be assessed and when **assessment methods are aligned with the teaching approach** (teaching one way and assessing in another is not effective). Students are more likely to succeed when a good proportion of the marks is allocated to students getting the 'right' answer where there is a known outcome. It is advisable for degree courses to **provide continuity and progression of CBL/PBL**, starting CBL/PBL in a simple way in year one and increasing CBL/PBL over the following two years. It is recommended that feedback is sought from students on an on-going basis and that sessions are adapted and enhanced in line with this feedback.

The approach is generally **popular with, and motivating for, students,** with attendance at sessions high, **and enjoyable for staff** to deliver. Students appreciate, and gain a great deal from learning chemistry within a ‘real world context’ and develop **a range of important skills,** which are essential for their studies and increase their employability. Section 6.6 provides further details on soft outcomes and skills development. Students also generally gain a lot from working with others in groups. As one student comments: ‘*I enjoyed it. The chance to discuss and debate with my peers about a range of subjects I find satisfying and interesting*’.

Lessons learnt

A number of challenges have been faced by the project partners, particularly those new to the approach, in delivering CBL/PBL. A key challenge for institutions is **gaining the interest and enthusiasm of academic staff** and convincing staff to give the approach a try. However, Nottingham Trent and Leicester have encountered less resistance than was initially expected. Also challenging has been **converting technicians** to the approach who are more familiar with more traditional experiments. In addition, allocating the staff time and resources (rooms, equipment, chemicals etc.) that are required to develop materials and deliver sessions can be challenging. The project partners new to CBL/PBL have experienced issues in relation to the **availability of instrumentation and chemicals**. There have also been issues in terms of accessing **suitable accommodation**. In some cases, due to pressure on space, lecture theatres and staff offices have been used for sessions which are not conducive to group work activities and can reduce the impact of the approach. Running CBL/PBL sessions is **staff intensive** and additional support (for example from postgraduates) is needed to facilitate and support the group work aspect.

Where CBL/PBL assignments have been designed from scratch, it has been commented that thinking of suitable contexts for some topics has been time consuming. Staff implementing this strand have learnt that **real skill is required to write successful context- and problem-based materials, and guidance** (for dissemination purposes), and that it is often a lack of time which inhibits invention in the curriculum. It has also been commented that, unless assignments are carefully written and the process is carefully managed, **student learning can be superficial**. Students can worry about the lack of content of the approach and, where appropriate, need to be given more confidence in and/or support in their information retrieval (‘*A lot is down to what you pick up – you may not learn everything needed*’ and ‘*Because sometimes the questions are quite broad, in terms of chemistry you could easily go off on a tangent, in the wrong direction*’). It is also felt that it would not be appropriate to deliver an entire course via the CBL/PBL approach and that there is need for moderation and a range of teaching methods. Students need exposure to motivating CBL/PBL contexts **but there continues to be a need to use more traditional teaching and learning styles**.

It is also important to note that this approach to teaching and learning requires a **significant amount of investment of time up-front** to counsel students about the teaching and assessment methods to be used and how they will be different to other methods that they have been used to. Students studying independently may also need more support than others in the early stages, particularly when using VLEs. In general, the approach is more **time intensive** than other more traditional forms of teaching. However, it **enables staff to engage more closely with students** which can be very rewarding. **Time management** within the module can be an issue because of the open-ended nature of CBL/PBL and staff need to manage the sessions within time whilst also learning strategies in relinquishing control – a delicate balance.

As they progress through the three years of their degree, students need to adapt to working with CBL/PBL scenarios where there is not necessarily a pre-determined outcome and in which they need to design the experiment, carry it out, understand what the outcome means and perhaps re-visit the procedure used. They also need to relate their experiences and progression in their report. To ensure that students understand what is expected of them and how they will be assessed, it is estimated that approximately 10 per cent of the time in CBL/PBL workshops needs to be spent on ‘**describing the rules of the game**’ and, from thereon, students also need to be provided with on-going support and reminded about the assessment method. This level of input is not required in a traditional lecture or tutorial situation and, in some cases, the additional time invested in the preparation stage can mean that time is limited later on. Students can find assessment processes where there is not a ‘right answer’ and in which they need to justify, and provide evidence for, their decisions and activities demanding and frustrating, at least initially, and this can lead to **lower marks than in other more traditional forms of assessment**. It is important not to confuse students' enjoyment with achievement – there may be a discrepancy between the two.

In relation to group work, **students find it challenging dealing with students in their group who are not delivering** ('*some people tend to sit there and do nothing*') and working in a group more generally when the group has not 'gelled' and this situation needs to be carefully managed by staff. Students suggest that peer reviews are a helpful way of identifying students who are 'not pulling their weight'.

The box below highlights what works well and the lessons learnt and challenges faced in implementing CBL/PBL.

What works well?	Lessons learnt/challenges
Delivery	***Development and delivery***
• The CBL/PBL approach is possible and the context can be simple • A 'blended' approach (i.e. a combination of CBL/PBL and more traditional approaches) is recommended over pure CBL/PBL • Continuity and progression within degree courses works well starting with CBL/PBL in a simple way in year one and then increasing input over subsequent years • CBL/PBL needs to take on different forms depending on the subject and works well when it is tailored to each situation/context • CBL/PBL can be effectively used through case study investigation and within laboratory work • The use of postgraduates to support the sessions is an effective mode of delivery and the skills that they develop can increase their employability • CBL/PBL works well when topics and information is presented in	• There needs to be commitment within the institution and amongst staff to go down the CBL/PBL route which is resource and time intensive • Some staff may need convincing or may lack confidence in going down this route, though confidence quickly increases with experience. Not all staff will want to deliver courses using CBL/PBL • It is time consuming to develop CBL/PBL materials from scratch and to adapt existing materials for a different context and sufficient time is needed for this – an additional staff member may need to be employed • More time is needed to implement CBL/PBL compared to more didactic learning methods • Single CBL/PBL modules are not effective • Running sessions is staff intensive as more staff are needed to facilitate and support the group work aspect • Accessing other resources for

lectures prior to CBL/PBL activities being initiated

- Pre-laboratory work is effective in preparing students for the laboratory work and making a more dynamic laboratory session
- Experiments work well when they build confidence and a sense of achievement
- CBL/PBL works best when assessment methods are aligned with the teaching approach (teaching one way and assessing in another is not effective)
- Since staff engage more closely with students, they can provide them with better support and give students better feedback on their progress
- Gaining on-going feedback from students and adapting sessions in line with this is important

Student response

- CBL/PBL is popular with students who find it motivating and enjoyable
- Students enjoy the content and its relevance to chemistry in the workplace; they see that learning the chemistry has a purpose and they appreciate the skills they are learning
- Students are usually well motivated and attendance is high
- Students develop a range of skills – see outcomes and impacts section
- Students do well when they have a good understanding as to how they will be assessed
- Students are more likely to succeed where a good proportion of the marks are allocated to students getting the ‘right’ answer where there is a known outcome
- Students from non-traditional learning backgrounds often do better

Staff response

sessions can also be an issue including physical resources such as rooms, equipment, chemicals

- Time management within the module can be an issue because of the open-ended nature of CBL/PBL
- Facilitating interactive sessions with students rather than giving presentations requires a greater level of engagement with students - but is often more rewarding. The success of CBL/PBL is highly dependent on the skills of the facilitator - encouraging discussion and debate and promoting a deeper understanding is crucial
- The staff member has less control over the direction that sessions move in and no two sessions are the same; staff need to learn strategies in relinquishing control and be comfortable with this approach
- It is important not to confuse students’ enjoyment with achievement – there may be a discrepancy between the two
- Students studying independently may need more support than others in the early stages, particularly when using VLEs
- Lazy group members and groups that don’t ‘gel’ can be a source of dissatisfaction for students and these situations need to be managed by staff
- If materials are to be disseminated it is important that detailed teacher guidance is produced
- Using CBL/PBL is costly and it may not always be a viable option for institutions

Student response

- Students are often unfamiliar with this approach to teaching and learning and significant time up-front is needed to introduce them to the approach and assessment methods and on-going guidance is needed

• Staff can find the approach more enjoyable and rewarding than others since they engage more actively with students; this can increase the motivation of staff for teaching • CBL/PBL works well when staff retain flexibility in delivery	• Students can initially find the approach frustrating and demanding before they adapt to and appreciate it • Students can worry about the lack of content of the approach and need to be given more confidence in the information they retrieve • A small minority of students are uncomfortable with giving presentations and this being a mode of assessment • Students are often more used to the exam style of assessment which can impact on their marks in assessments – they can find it challenging to justify and provide evidence for their decisions and activities

6.6 Outcomes and impacts

This section draws together information from across all of the project partners in relation to the range of ‘soft’ and ‘hard’ outcomes and impacts which have emerged from the use of CBL/PBL approaches. This includes ‘soft’ outcomes for students, staff and institutions more generally and hard data in relation to student attainment.

Outcomes and impacts for students

Soft outcomes

Data gathered from the project partners suggests that **CBL/PBL approaches lead to a range of important outcomes for students.** These are all in addition to the chemistry content that they learn.

Key seems to be the **group and team work skills** that students develop from working together with others in small groups. For example, one student reports: ‘*It teaches you to work in a group with different group members*’ and another comments on the opportunity for ‘*getting my opinion across*’. Students also report that, through group work, they have learnt from others and come to solutions they might not have come to on their own. As two students comment: ‘*It gives the opportunity to discuss things within groups, which means we may find solutions to problems we may not have thought of by ourselves’* and ‘*Get to work as a team to come up with the best solutions*’.

Also important are the **strong bonds and friendships** which students develop and which can have a positive impact on retention: ‘*PBL creates a community of students and strong links between students and staff. It really helps; students feel part of the department and are more likely to want to stay*’. These developing friendships have been particularly evident in Leicester where CBL/PBL approaches have been used in the first semester of the first year. Working in small CBL/PBL groups has helped students to fit into university life quickly and it is felt that this has had a very positive impact on the culture of the chemistry department. It has also impacted on students’ willingness and confidence to contribute in other tutorials and on their confidence in interacting with each other and with staff. Because students find the group work and more investigative approach to learning more engaging than more traditional approaches, attendance in sessions is, as a result, generally high.

As well as group and team work skills, students gain other **important transferable skills** such as communication, problem solving, critical thinking, research, decision making, presentation skills, IT skills (particularly those working independently), planning, task and time management and report writing. Students appreciate the fact that they are able to apply their learning to problems - ‘*It’s about applying rather than just learning*’ - and that they have to think through solutions to problems, which can include putting theories into practice - ‘*We were made to think and make our own minds up as to what the answer was and why*’ and ‘*We are given a chance to think, rather than just accepting what we are presented with*’ and ‘*Development in logical and lateral thinking*’. The approach involves students much more than in traditional lectures and reading books: ‘*It’s a lot more hands-on rather than an hour of being talked to. Understanding comes from discussion rather than hours of books*’. Within laboratory work, involving students in developing the experimental design supports their understanding and application of theory. Students working by themselves also develop skills in independent learning. All of these skills are valued by employers and they are also important in relation to students’ success in studying. The project partners feel that these skills are best developed within a chemistry context rather than in a stand-alone module.

Also a key impact is **students' increased understanding of the application of chemistry within the real world** and of what chemists do within the workplace and students applying knowledge and theories to a real life situation. Students' comments on this area include: '*It mimics industry*', '*The idea is really good where the problems are related to real life, applying scientific knowledge to real-world situations*' and '*It allowed us to put our subject knowledge into practice and see how it could be used in a real life situation*'. Students also report that, through the CBL/PBL approach, they are more likely to retain information: '*It makes it more interesting and you are more likely to remember things you have found out yourself and put to use*'. Seeing the application of chemistry in the workplace is seen to have a key impact in terms of **increasing students' motivation for their chemistry studies** and it helps in terms of career decision making.

The skills developed through CBL/PBL are also felt to **increase students' employability.** In particular, students can draw on their learning in employment interviews: '*Companies like people who can solve problems*'. The record of students from Plymouth gaining employment within chemical industries is high; 75 per cent gain jobs in this sector as opposed to the national figure of 30 per cent. The project partner at Plymouth feels that the high proportion of students at Plymouth gaining employment in chemical industries is related, to a certain extent, to the CBL/PBL approaches that are used.

Also key to the CBL/PBL approach is the need for students to think in a different way to that they are used to and to **apply materials and learning from previous modules.** Although students initially find this approach challenging, they benefit in terms of exam performance and employability.

Hard outcomes for students

The key finding from Plymouth's analysis of student assessment and performance data for case study activities over the past seven years is that, if you assess CBL/PBL using assessment procedures and criteria which are familiar to students, then they do as well as in other more traditional methods of teaching and learning within the same module. Although they may be unfamiliar with the contextual and, in some cases, open-ended nature of the problems within the case studies, **students still do well if they are familiar**

with the assessment methods i.e. if a high proportion of **marks are allocated to students achieving the required solution**. However, it is felt that, **where assessment criteria is more open ended and there may not be a right answer** and where, for example, students are required to discuss their reasons for their decisions and actions, demonstrate a sensible rationale for the methodology and evaluate the effectiveness of the group work, **performance can be lower than in other types of assessment**, such as laboratory reports, even if the subject matter is similar.

Students' difficulties with this type of assessment are not usually linked to a lack of clarity in the lecturers' description of the assessment process - as half a session is dedicated to this - but more to students finding it difficult to adjust to a new approach to assessment.

Leicester have found that using CBL/PBL with year one students has not impacted either positively or negatively on students' marks. This is perceived to be a very positive outcome since students also gain a range of important skills through the CBL/PBL approach.

In terms of retention, the evidence that has been collected to date (particularly at Leicester) suggests that **CBL/PBL does have a positive impact on retention** since students enjoy the approach to learning and gain significant benefits from working together in groups. The group work element supports first year students to forge close friendships which can make a significant difference to their enjoyment of university life and their desire to continue their studies.

Outcomes for staff

In terms of staff, the project partners feel that the piloting of CBL/PBL approaches via this project has led to increased **interest, confidence and skills amongst staff** in using the approach. There are now some individual 'champions' of this approach and, in some cases, teams of staff, who can, over time, persuade others to come on board.

Staff within the partner institutions have also commented that they benefit from being able to have **a different kind of contact with students** which includes the opportunity for staff to mingle with students as they work together and gain a greater understanding as to how they work. Staff have also benefited from an increased confidence amongst students in working together and more confidence in their interactions with staff. As one staff member comments: '*PBL creates a community of students and strong links between students and staff. It really helps; students feel part of the department and are more likely to want to stay*'.

Also of benefit has been the **teaching experience gained, and skills developed by, the postgraduate students** who have supported the delivery of sessions in Leicester.

Outcomes for institutions

The funding has **increased partnership working** and the **sharing of knowledge and experiences** between the four university project partners. Although all of the project managers from the four universities knew each other before, they had not worked closely together. They were also at very different stages in relation to the delivery of courses via the CBL/PBL approach with Hull and Plymouth having developed real expertise over several years and other institutions, such as Leicester and Nottingham Trent, being relatively new to the approach. CFOF funding has been helpful in that the project partners have been able to explore different aspects of delivery and to come together to share different levels of knowledge and experience. In addition, working together has enabled the four project partners to speak with a **unified voice** which has made it much easier to 'sell' the approach to other institutions.

There have also been some unintended impacts. For example, the project partner at Leicester has commented that the teacher fellow based at the University of Nottingham (see section on Strand 2) has observed a CBL/PBL session being delivered at Leicester and has gone back to the University of Nottingham with ideas as to how the delivery of the chemistry course there might be enhanced.

6.7 Additionality

Within the universities new to CBL/PBL approaches, the CFOF funding for this strand has been instrumental in initiating change and 'unlocking doors'. It has allowed steps to be taken to build interest and confidence in the use of CBL/PBL and has shown staff what can be achieved through this approach.

The funding allocated has been of value in that senior managers have been more inclined to try out new approaches and have been prepared to take the risk.

Within Hull and Plymouth, where CBL/PBL approaches have been used for several years, the CFOF funding has allowed staff to collate and analyse evaluation data to demonstrate the impacts of this approach on both students and staff.

It is strongly felt that none of the activities which have been supported under this strand would have been delivered in the absence of the funding.

6.8 Next steps/future plans

Within the universities new to the CBL/PBL approach (Leicester and Nottingham Trent), the challenge for the future will be sustaining the approach and the momentum that has been achieved. The next step for these institutions is now to look at the whole three year curriculum and include CBL/PBL approaches in every term and every year where topics lend themselves to this approach to teaching and learning. These project partners acknowledge that there are different challenges in embedding this approach in year three but the positive aspect is that students will have an increased knowledge base to draw on at that level, although the CBL/PBL approach does, in itself, include the gaining of knowledge.

The next stage of development for Plymouth is to design some more first year CBL/PBL laboratory sessions so that they have a suite of five or six to deliver with students. Each session requires students' sheets, notes and materials for the tutor, health and safety documentation and assessment criteria. The new sessions will follow the model which has been shown to work.

The University of Hull intend to take materials that they have been using for a number of years and update and extend them, including adding international examples. They want to ensure that students understand that the chemical industry is a global industry and not a local industry and raise students' awareness of the usefulness of language skills.

All partners also agree that there is a need for more easily transferable and ‘off the shelf’ CBL/PBL materials and resources to be developed which can encourage and enable other chemistry departments new to CBL/PBL to start introducing this approach. To date, the resources developed have tended to focus on applied topic areas; the challenge for the future will be developing CBL/PBL resources for other core curriculum topic areas. A key priority will be to develop transferable resources covering a wider range of core curriculum areas. If materials are to be widely disseminated, the guidance for both staff and students needs to be clear and comprehensive. Wider dissemination of learning and best practice in relation to CBL/PBL teaching and learning and of CBL/PBL materials will continue to be a priority for the strand.

7. Strand 3.3: Open-learning Framework for Part-time Provision

This section presents an overview of the progress of Strand 3.3, the part of the HE curriculum development strand that is focused on developing an open and distance learning framework for part-time HE students in chemical and analytical sciences. It includes findings related to progress, issues that have impacted on delivery, additionality, and next steps. It draws on interviews with all five project partners.

7.1 Key findings

- The project originally aimed to develop an **open and distance-learning framework** to sustain the future of part-time HE provision in chemical and analytical sciences. However, the aims and objectives of the strand were amended as the partners considered them **too ambitious**. Instead, the group agreed to concentrate on **developing six modules** (120 credits) of part-time distance learning provision: access to chemistry; structure and bonding; organic chemistry; physical chemistry; analytical chemistry; and learning at work (to be developed if an extension phase was funded).
- The **changes made to the project** after its agreement by HEFCE and the time taken to issue and then agree **contracts** delayed the projects. This led to a **staggered start** across institutions, and prevented some institutions from recruiting **project staff**. More **lead-in time** for projects would have enabled them to have the right people and plans in place at the start date.
- However, despite the difficulties experienced, at the time of interview, project partners were confident that the **five modules due for delivery would be completed by the end of August 2008**. The modules will be for distance learning use, and comprise on-line presentations of course content, which is linked to textbooks and includes hyperlinks to supporting material (e.g. websites). Modules will be able to be used **'off the shelf'** or **customised** to the needs of specific courses and students.
- Although partner organisations were already delivering part-time chemistry degrees and were in the process of developing some distance-learning materials, the activities did demonstrate **additionality**. Firstly, materials have been produced at a **much higher standard** than they otherwise would have been, and secondly there is the **sharing across the chemistry community** that has taken place as a result of the partnership working.
- Two partner institutions have firm plans to use the materials, and a further two partner institutions may use them. There also needs to be **active dissemination** to promote use of the materials beyond the project partners.

7.2 Introduction to Strand 3.3

This chapter presents an overview of the progress of Strand 3.3, the part of the HE curriculum development strand that is focused on developing an open and distance learning framework for part-time HE students in chemical and analytical sciences. The chapter builds on data from the interim report, by drawing on interviews with all of the university partners delivering modules, one of whom was the coordinator of the Strand. The interviews were carried out in June 2008, two months before the deadline for completing the project and after the decision had been made not to fund any activity in the extension phase.

Whilst evaluation activities across the rest of CFOF are focused on identifying and measuring impacts arising from the programme, the aim for Strand 3.3 was different, as the aim of the funding was to develop materials, not put them into practice. Therefore at this stage, there can be no measurable impact. Consequently, the interviews focused on:

- progress made and anticipated before the end of August 2008
- issues that have arisen during the project and their impact on delivery
- additionality of the activities
- future plans/next steps.

The aims of Strand 3.3

- Strand 3.3 was allocated £300k in total, and the project originally aimed:
- to customise and focus the expertise and resources of the consortium of stakeholders to underpin sustainable development of part-time education in chemical science
- to develop a national upskilling curriculum resource for distance learning HE provision
- to develop new curriculum resources and appropriate pedagogy that will integrate with modern learning technologies and serve sector industries
- to enhance the accessibility of part-time study and expand e-learning capacity in the sector
- to support the integration of under-represented sectors in HE: new entrants without formal qualifications, mature-learners, career-break returners, improvers, updaters and specialisers
- to underpin and expand existing part-time provision for those in chemical science employment across England
- to produce a foundation portfolio of modules in chemical and analytical science of importance to large GNP-producing industries such as chemical, pharmaceutical, nuclear, polymer, food, health, materials, as well as service-sector businesses such as environmental monitoring, quality control, forensics etc.
- to build the foundation of a transferable, industry-standard CPD model for technical and professional career chemists generally.

However, at the initial meeting of the project partners in November 2006, after HEFCE had agreed the CFOF bid with the RSC, the aims and objectives of the strand were amended as the partners considered them too ambitious. Instead, the group agreed to concentrate on developing six modules of part-time distance learning provision, totalling 120 credits (see Table 7.1 below). However, due to the strand coordinator at Manchester Metropolitan University leaving the university, there was no capacity there to develop the ‘learning at work’ module before August 2008, and it was agreed that this module would be developed in the extension phase.

Table 7.1: Modules to be developed following revision of Strand 3.3 plan

Module	HEI Level	Developer
Access to chemistry	0	Open University
Structure and bonding	1	Hull
Organic chemistry	1	Manchester
Physical chemistry	1	Greenwich
Analytical chemistry	1/2	Brian Woodget (consultant)
Learning at work	1/2	Manchester Metropolitan

7.3 Progress to date

In June 2008, all of the project partners reported that they were close to finishing their modules of the framework, and along with the strand coordinator, were confident that they would have complete versions ready by the end of August 2008 deadline. These finished products will be able to be used 'off the shelf' in their current form as part of any university's course. They are also designed to be flexible, so that universities can adapt them to the specific needs of their course and students.

7.4 Issues and their impacts on delivery

Various issues impacted on the delivery of the project:

- **changes made to the project** after submission of the proposal to HEFCE caused delays to the project timescale. Some interviewees felt that the delays could have been avoided by thinking through all the issues prior to submission to HEFCE, whilst others felt that they had done what they could in the short time available. It was generally agreed that the changes were necessary to make the project achievable and ensure a quality product
- further delays were caused by the time taken to issue **contracts**, and for universities to agree the contracts due to their length
- delays meant that universities started working on their modules at different times. This **staggered start** ensured that institutions did not independently create five components that were not consistent with each other. However, more working in parallel could have led to more interaction and cross-fertilisation of ideas between institutions

- delays also meant that some universities were not able to **appoint project staff** as this would have caused further delays whilst they recruited. Building in enough time to appoint such staff is important, given the significant time needed for universities to recruit
- some interviewees would have preferred a tighter **style of management** to keep them on track and ensure consistency (e.g. setting out a basic layout for the materials at the start of the project, more regular meetings). However, it was suggested that if the project had been more tightly managed, it would have been more expensive, and there may not have been the same level of buy-in from partners
- some interviewees felt that a **dedicated project coordinator** could have added value to the process, and aided the production of learning materials across several sites
- the **busy schedules** of project partners means that they have had little time in which to carry out project work: 'It's always a problem when something like this is essentially on top of everything else. It gets done to some extent in the margins of one's time'.
- having **IT support** available could have helped with the technical side of producing materials
- slow **internal systems** (e.g. setting up budget) exacerbated other delays.

7.5 Additionality

The activities funded through Strand 3.3 did demonstrate some additionality. Although all the partner institutions have part-time degrees in chemistry and were already developing some distance learning materials, the Strand 3.3 funding led to:

- a much higher production standard of materials than there otherwise would have been
- significant sharing across the chemistry community as a result of the partnership working.

7.6 Next steps

With no extension funding for the project, there are no formal plans for taking the work forward. Interviewees recommend active dissemination to ensure that other chemistry departments are made aware of the materials. It is expected that at least two, and possibly four of the institutions involved, will be using some of the modules in the next academic year. More definite plans include:

- material produced at **Hull** will be trialled there next semester (September 2008) with their part-time students, and feedback will be gathered. The material will also be made available as a resource for their full-time students. Other Strand 3.3 modules may also be used at Hull, but no decision will be made until the final materials are available
- **Greenwich** are planning to offer a part-time distance learning HNC or foundation degree, and would like to use the materials produced by all the partners as part of the course.

In general, project partners feel that an opportunity has been missed by not providing funding for the extension period. Further funding would allow:

- materials to be trialled with students and further refined and developed, which could turn '*… good material into really excellent material*' (strand coordinator)
- development of a sixth 20 credit module 'Learning at work' which was to be an in-work practical experience module, and would have complemented the other five modules.

As government policy and the HEFCE agenda is increasingly focusing on employability and employer engagement, not funding the open learning framework further is considered as a missed opportunity.

8. Strand 3.4: Mastering Bologna

This section presents a brief overview of the progress and outcomes of Strand 3.4, which aims to create a strategy for UK chemical science degree programmes that will meet the requirements of the Bologna process.

8.1 Key findings

- **Strand management**, which involves Imperial and the RSC, has been **effective.**
- All activities have been completed and the data and findings are being **drawn together in a report** by Professor Tom Welton.
- The project is seen as **successful and very timely** and its key success is **raising awareness** of issues and potential solutions relevant to the Bologna process.

8.2 Introduction to Strand 3.4

Strand 3.4 is being co-ordinated by Imperial College, and aims to report on the degree of alignment of UK chemistry with the Bologna process, as well as any changes necessary to achieve alignment. The information presented below is drawn from the RSC's September '08 report to HEFCE; an interview with the Strand 3 leader; and interviews with four members of the RSC Steering Committee and/or Project Advisory Group.

The aims of Strand 3.4 are to:

- determine the funding requirements for the additional year of training in the Bologna Masters (notably the second year of Masters training)
- map out key areas of masters provision that would be best undertaken under the aegis of a Chemistry Department
- determine the levels and models of masters course provision required for the industrial and academic base
- determine how the Bologna structure can be integrated with non-Bologna models for the internal UK market and the international market
- develop models of Masters training that enable inclusion of mature students and short-course activities for industry
- develop common entry and exit points under the Bologna model in order to optimise recruitment levels
- monitor developments with the Bologna Process throughout Europe.

8.3 Strand management

The project is led by Imperial College London, with a steering group that involves seven other institutions (University of Bath, University of Birmingham, Durham University, University of Huddersfield, Liverpool John Moore's University, University of Nottingham and University of St. Andrews). The Strand 3 leader feels that the management of the strand has been effective, and that the relationship between staff at Imperial College London, who oversee academic issues, and the RSC, who manage the project, works well.

8.4 Progress to date

A survey of the perceptions of the heads of chemistry departments regarding compatibility with Bologna has been carried out. Compatibility data has been collected for undergraduate and postgraduate courses. Eleven institutions have been involved in SWOT (strengths, weaknesses, opportunities, threats) analysis meetings that were facilitated by an independent consultant. The data and findings from the project are being drawn together in a report by Professor Tom Welton.

8.5 Outcomes and impacts

The project is seen as successful and very timely by the Strand 3 leader as well as by members of the RSC Steering Committee and Project Advisory Group. The key success of the project is the way that it has raised awareness of what Bologna is, the issues for UK institutions in becoming Bologna compliant, and what actions universities could take to become compliant.

9. Strand 4: Widening Schools' Access to University Laboratories

This chapter presents the first year evaluation findings for Strand 4, Widening Schools Access to University Laboratories. This strand is being run in two universities which are trialling two distinctive approaches to schools' use of university laboratory facilities with the aim of enhancing pupils' experiences of practical chemistry.

The chapter includes detailed information on the outcomes of the strand, drawing on perceptual and statistical data. Findings are based on consultations with the overall strand manager, the two laboratory managers at each of the universities, and with school teachers and pupils.

9.1 Key findings

- The Universities of Bristol and Sheffield have **not achieved targets** to work with 2,000 and 1,500 school pupils respectively. The University of Bristol has worked with 47 schools and 689 school pupils as part of this project and the University of Sheffield has worked with 21 schools and 399 school pupils, as well as delivering training and CPD to PGCE students and school teachers. During the initial year, greater emphasis has been given to promoting the facilities, establishing systems for running the provision and designing and trialling practical activities. **Both universities have worked with a broad spectrum of schools and age groups.**
- The **provision is well received by teachers and pupils**, and is noted for its: emphasis on practical work/experimentation; curriculum enhancement; the teaching expertise of deliverers, including appropriate pitch and level; contact with undergraduates and postgraduates; flexibility and tailored activities; quality of the facilities and equipment, and; the university experience.
- **Key messages for the development of the strand** are identified in terms of **ensuring sustainability** and manageability of the provision (e.g. **funding arrangements**, administrative support and staffing); continuing to develop partnerships with schools; the development of specific activities, including maximising the capacity and depth of impacts enabled by full day activities and summer school activities, and; greater integration and emphasis on careers information.
- **Schools' use of university laboratories has strong positive outcomes on pupils, such as increases in**: enjoyment of chemistry, chemistry knowledge and skills, and awareness of HE. Where these impacts are strongest, it seems that the strand has the capacity to affect young people's behaviours and decisions around further chemistry study and careers.

- The strand also has **CPD impacts on the teachers** involved, particularly in terms of enhancing their: links with HEIs/industry/other schools, access to resources, and capacity to support and advise pupils regarding further chemistry study and careers.
- **Impacts for universities** include academics' learning around effective curriculum enhancement outreach with schools, increased student recruitment to the institution from the schools that have used the labs, enhanced links with other HEIs including the sharing of practice around schools use of university laboratory facilities.
- The **evidence supports and endorses both models** of schools' use of university laboratory facilities. In each model, there are positive outcomes, and challenges. Both models could be applied to other universities depending on their specific circumstances.

9.2 Introduction to Strand 4

This strand, Widening Schools' Access to University Laboratories, is being run at the University of Sheffield and University of Bristol in partnership with schools in the respective areas and is aimed at enhancing school pupils' experiences of practical chemistry. Two different approaches to widening schools' access to university laboratories are being trialled by the universities:

- a designated schools- laboratory in Sheffield, available to schools at any time during the year which has a maximum capacity of 15 students
- downtime laboratory use at Bristol with availability for schools-use on Wednesdays only, with a large capacity of up to 200 students at a time.

The aims of Strand 4 are to:

Sheffield:

- use designated university facilities with up to 1,500 AS and A2 school students
- produce a range of curriculum based pre-packaged experiments.

Bristol:

- use university facilities with up to 2,000 school students
- develop two-day taster sessions for year 11 students who have just completed GCSEs
- develop a suite of experiments for key stage 4, AS and A2-level students
- offer revision workshops for GCSE students focusing on structure and bonding, energy and organic chemistry

- offer research opportunities for students performing extended A-level projects.

The evaluation methodology for this strand included case studies with five schools (including interviews with 23 pupils and five teachers); survey administration to 95 pupils; follow-up telephone interviews with three teachers; initial and follow-up interviews with the laboratory managers from each site (Bristol and Sheffield); and consultations with the overall strand manager.

9.3 Strand management

This strand of CFOF has an overall manager based at the University of Bristol, as well as managers based at each of the universities. The two members of staff responsible for the actual running and delivery of schools use of the laboratories are in close contact and there seem to be lines of communication for exchanging good practice.

It is felt that the strand is being effectively managed, with **good working relationships established between the project leaders at each of the participating institutions and the RSC**. The overall management style has been reasonably light touch, so as to enable the projects to develop independently and with the aim of comparing the two distinctive approaches to this type of intervention. During the initial year, emphasis had been placed on exploring the challenges and solutions associated with running such interventions, to which the sharing of learning across the two projects had been crucial. During the extension phase, even more emphasis will be given to implementing this learning. The extension phase evaluation will explore further opinions on the two models, and the sharing (or otherwise) of ideas between the two.

9.4 Progress to date

The progress of Strand 4 in relation to outputs and spend

The total funding allocated to Strand 4 for the period 07-08 was £200,000 (for both projects at Bristol and Sheffield). All of this funding had been committed by September 2008 (although some invoices were outstanding).

The Universities of Bristol and Sheffield have **not quite achieved targets** to work with 2,000 and 1,500 school pupils respectively. Since the beginning of the project in the Autumn term 2007, until the end of the Summer term 2008, the University of Sheffield has worked with 21 schools and 399 pupils, as well as delivering training and CPD to PGCE students and school teachers (the latter as part of the RSC Chemistry for Non-specialists Programme). The University of Bristol has worked with 47 schools and 689 pupils as part of this project.

During the initial year, greater emphasis has been given to promoting the facilities, establishing systems for running the provision and designing and trialling practical activities. **Both universities have worked with a broad spectrum of schools and age groups.** At both sites there is also evidence that schools are making repeated visits to the facilities over the course of the academic year. Both sites have engaged with a range of pupil age groups, primarily key stages 4 and 5, but also key stage 3 pupils. Targets to produce and design the experiments and workshops have been achieved, although these continue to be trialled and added to.

Progress and activities at Sheffield

The activities run at Sheffield are practically based laboratory work and experimentation. These are often coupled with lectures and talks from specialists from the university, tours of the department, and demonstrations/presentations on spectroscopy equipment. Undergraduate chemists (with an interest in pursuing a career in school teaching) support the pupils in carrying out the practical work. Other events held at the University of Sheffield schools' laboratory include chemistry competitions and a week long summer scholarship programme for post-16 pupils to develop their practical skills and awareness of undergraduate chemistry. Training for PGCE students and teachers has also been delivered at the university schools' laboratory.

In the initial developmental year, the laboratory has not run at full capacity (i.e. it was usually booked for schools' use one day a week, although for several weeks, sessions were run three days of the week). The emphasis of the work has been on establishing the necessary structures and practices and promoting the facility to schools. Plans are in place to operate the schools' laboratory facility three days per week in the year ahead in order to achieve full capacity. The teacher fellow who has been running the laboratory in its initial year has been employed by the university on a permanent basis to run the laboratory one day a week next year. Recruitment is currently underway for an additional member of staff to run the facility for a further two days per week. School bookings have already been taken for the coming academic year, including existing and newly engaged schools. It is believed there is now a good level of awareness of the facility amongst surrounding (and indeed more distant) schools.

Progress and activities at Bristol

In Bristol, again, the activities involve practical work, where school pupils are supported by postgraduate SEAs (Science and Engineering Ambassadors). Schools' visits to the university laboratory are often combined with a tour of the university chemistry department and a lecture demonstration. The workshops aim to give pupils a taste of what it is like to be an undergraduate chemistry student. As part of the Strand 4 project, the University of Bristol also run a University Chemistry Experience Camp. This is a two-day programme of activities for potential post-16 chemists comprising of practical sessions in the laboratories, lectures and talks and a spectroscopy tour. Another activity partially funded through the Strand 4 project is a week-long session of practical work for post-16 pupils, held jointly with a higher education institution in Dublin.

Schools' use of the university laboratory facilities at Bristol is felt to have operated at almost full capacity throughout the initial academic year, being available on most Wednesdays throughout term-time and at the point of overlap between university and school term times. The project is progressing as expected and there is felt to be growing awareness of the facility amongst schools – the laboratory is almost fully booked for schools' use for the 08-09 academic year until Easter and schools are tending to book well in advance. A range of schools are using the laboratory, although the type of school engaging tends towards the independent sector schools, and less so the 'widening participation' schools.

Targeting strategy and engaging participation

Both universities have been engaged in sending promotional materials and communication to schools regarding the laboratory facilities. The facilities are also advertised as part of the universities' wider outreach programmes, including via schools liaison and outreach colleagues working out in local schools. In addition, both sites have further developed their website capabilities, providing information to schools about the university laboratory facilities, the types of activities that are available and details of how to book.

Sustainability

The sustainability of the Widening Schools' Access to University Laboratories project needs considering. At present, Sheffield does not charge schools to use the facilities. Bristol charges schools a subsidised fee per head. The Sheffield laboratory has secured the donation of **chemicals from industrial partners**; and the Bristol laboratory is able to build on its work in **other similar initiatives** (e.g. the Bristol ChemLabs project) **to help support this work**.

One of the laboratory managers feels that the lab activity is sustainable: '*It sells itself, the number of people and the distance people are coming – it's getting bigger. We feel it's sustainable, it will be a new audience each year, schools come along and say it fits perfectly with what they're doing, then of course they can bring a class every year*'. However, it is clear that **more work needs to be done to consider sustainable funding for such activity**. Sources of funding, for these laboratories and other universities considering developing such laboratories could include: **charging schools** for use (however, see section 9.6 on challenges and barriers), **industrial sponsorship**, university partnerships (e.g. **local universities pooling budgets** to develop a shared lab space), charging for **teachers' continuing professional development** activities in the laboratories (i.e. not just young people focused activities), and developing the laboratories alongside **other funded initiatives and sources of funding**.

9.5 Outcomes and impacts

This section examines the impacts of the Widening Schools' Access to University Laboratories project on those involved.

9.5.1 Outcomes and impacts for pupils

This section examines the impacts of Strand 4 on the school pupils involved. A sample of teachers and pupils who have experienced a visit to a university laboratory have been consulted from each of the two projects – from four case study schools. Three of these schools are above the national average in terms of the proportion of pupils achieving 5 or more A*–C grades at GCSE or AS/A level point scores, and one school is below average. Data are drawn from survey questionnaires with 95 pupils; semi-structured interviews with 23 pupils (from year groups 10-13); 5 teacher interviews and 3 teacher follow-up interviews; initial and follow-up interviews with the laboratory managers from each of the projects (Bristol and Sheffield), and; consultation with the overall strand manager.

This section will:

- describe the pupil sample in terms of their attitudes to chemistry, chemistry further study and higher education
- consider, thematically, the types and extent of outcomes for pupils from participating in this strand (including knowledge, skills and attainment in chemistry; awareness and understanding of HE, chemistry in HE and chemistry careers; attitudes and perceptions of chemistry; and future intentions and participation in chemistry). Each theme explores the initial questionnaire data, pupil views, teacher views, and other views (e.g. laboratory manager and strand manager views).

Pupils' attitudes to chemistry

The initial survey questionnaire asked pupils to rate a series of statements on a 1 to 5 scale (with 1 representing a negative response and 5 a positive response) in order to gauge their overall attitudes to chemistry. Their responses are presented in Table 9.1 in a rank order with the most positive responses listed first.

Table 9.1: Attitudes to chemistry, chemistry further study and HE: Strand 4 pupil survey sample

Statement	Mean value
I do not intend/do intend to go to university	4.6
I do not enjoy/enjoy chemistry	4.2
Chemistry is not useful/is useful for jobs/careers	4.1
I do not like/do like the way chemistry is taught	4.1
I don't know/do know a lot about higher education	4.0
I do not feel/do feel prepared for higher education	3.9
I am not doing/am doing well in chemistry	3.9
There aren't/are interesting/exciting chemistry careers	3.9
Chemistry is not useful/useful for everyday life	3.8
I don't know/do know a lot about what chemists do	3.5
I am not/am aware of a range of chemistry careers	3.4
I do not/do intend to take chemistry further as a subject	3.4
Chemistry is hard/easy	3.1
I do not intend/do intend to take chemistry for a job/career	2.8
N=95	

Source: NFER pupil survey, 2007-08
A total of 95 respondents gave a valid response to at least one of these items

Table 9.1 shows that the sample of pupils consulted already have strong intentions to go to university (mean rating of 4.6). The pupils feel that they know quite a lot about university and higher education, and feel well prepared for this phase of their education (rating these items on average as 4.0 and 3.9 respectively).

The respondents also appear to hold positive attitudes towards chemistry, including enjoyment (mean rating 4.2), positive perceptions of its relevance and usefulness for jobs and careers (mean rating 4.1) and, to a slightly lesser extent, the usefulness of chemistry for everyday life (mean rating 3.8).

Pupils also report that they like the way chemistry is taught in school (mean rating 4.1) and tend to feel they are doing well in chemistry (mean rating 3.9) (indeed, by their predicted grades, the majority of the sample could be considered as high achievers).

The respondents are more ambivalent in their views about how difficult they perceive chemistry to be (mean rating of 3.1). However, this finding suggests these pupils do not find chemistry too hard, as is often a criticism of the subject.

The pupils seem slightly less confident about their knowledge of what chemists do and their awareness of a range of chemistry careers (mean ratings of 3.5 and 3.4 respectively), although a higher proportion felt they had this knowledge than did not, and were positive that there are interesting and exciting chemistry careers (mean ratings of 3.9).

A slightly higher proportion of the sample of pupils intended to take chemistry further as a subject, represented by an average rating of 3.4, though fewer intended to pursue a chemistry career (mean rating 2.8).

The results discussed above, overall, suggest that the sample of pupils consulted as part of this evaluation have, relatively, very positive attitudes towards chemistry and chemistry further study. Although this evaluation did not include a formal comparison sample, it is widely accepted that school pupils (particularly pupils towards the latter phase of secondary schooling) tend to have negative perceptions of chemistry, the relevance and use of chemistry and chemistry careers, and very few intend to pursue chemistry-related occupations. The positivity expressed by this sample of pupils towards chemistry may, in part at least, be due to the fact that these pupils attend schools which are engaged in chemistry outreach and interventions, and, often the pupils have experienced more than one type of chemistry activity during their schooling. Despite the overall positive chemistry attitude amongst the pupil sample, their attitudes towards pursuing a career in chemistry remain more negative, and most do not intend to choose chemistry as a career pathway.

Typology of the impacts on pupils

Attention shall now turn to consider a typology of the impacts emerging from pupils' experiences of practical work in a university laboratory environment. The key impacts of this experience have been on pupils' enjoyment of chemistry, chemistry knowledge and skills and awareness of higher education generally. The impacts have been categorised and will be discussed in the following overarching themes:

- Knowledge, skills and attainment in chemistry
- Awareness and understanding of HE, chemistry in HE and chemistry careers
- Attitudes and perceptions of chemistry
- Future intentions and participation in chemistry.

Knowledge, skills and attainment in chemistry

A range of evidence is available from the evaluation to show that the Widening Schools' Access to University Laboratories project has achieved a positive impact on pupils' knowledge, skills and attainment in chemistry. The initial questionnaire asked pupils to rate on a 1 to 5 scale (with 1 being 'not at all' and 5 being 'a great deal') the extent to which their experiences of such chemistry activities and events have made a difference to their knowledge and skills and how well they are doing in chemistry. Their mean response ratings are presented in table 9.2.

Table 9.2: Impact ratings: Strand 4 pupil survey sample

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Chemistry knowledge and skills	0	11	23	50	15	3.7
How well you're doing in chemistry in school	5	10	26	48	8	3.5
N=95						

Source: NFER pupil survey, 2007-08
A total of 94 respondents gave a valid response to at least one of these items

Pupils gave an average response of 3.7 and 3.5 for each of these items on the 1 to 5 rating scale. Sixty-five per cent of pupils rated the impact on their chemistry knowledge and skills with a 4 or 5, indicating that the experience has made 'quite a lot' or 'a great deal' of difference. Fifty-six per cent of pupils gave a 4 or 5 rating suggesting that the experience has made a difference to how well they are doing in chemistry in school.

Pupil views

Qualitative discussion with the pupils themselves and their teachers reveals a similar degree of impact from the project on pupils' knowledge, skills and attainment in chemistry and provides further details as to the nature of these impacts. The vast majority of pupil interviewees (22 out of 23) report that their experience of visiting a university laboratory has affected their chemistry knowledge and skills at least to some extent. The pupils describe how the experience has impacted on their knowledge and skills. Their views are outlined below.

- Provides the opportunity for **revision and reinforcement of prior learning**, as well as the opportunity to put theoretical and textbook learning into practice, thus learning in a more practical way, as one pupil outlines: '*It makes it easier to understand when you can actually see it, rather than just learning about it in a book*'.
- Develops **practical skills and techniques**, including access to different types of equipment (often unavailable in school) and learning how to set this up, how to use different chemicals, mix substances and exert control over the experimental environment, such as monitoring temperature and amounts of chemicals used. One pupil reports: '*I learnt quite a bit actually about how to extract it* [caffeine] *and using the tools and that*'.
- Enhances **learning of chemistry topics and chemical understanding**, including extended understanding of chemical reactions, knowledge of new chemicals and developed knowledge of specific topics, such as nanotechnology. As this pupil explains: '*It advanced how I thought about how things work, my understanding of different reactions. It was building on stuff I already knew and then introducing new things as well, new things about different practical skills and different reactions*'.
- Learn **how chemistry is used in 'real life'** and about chemistry beyond the classroom, with a feel for experiments which relate to industrial chemistry and everyday applications of chemistry, e.g. perfume and paracetamol. As this pupil describes: '*It widened it more, normally chemistry used to be like, I like it, I sit in class and learn everything, but when I actually did it makes it feel like there is more to it than just what is in the class*'. Additional feedback data collected from four schools where pupils visited the University of Sheffield laboratory confirmed this impact, as pupils unanimously responded that they had gained an awareness of what practical chemistry was like.

Although pupils often feel that the experience of the university laboratory visit has aided their understanding of chemistry, bolstered their interest in the subject and helped them develop their practical skills, they are more sceptical about whether this has translated into improved attainment and achievement in the subject. Less than half of the interviewed pupils (9 out of 23) feel confident that the laboratory visit has impacted on **how they are doing in chemistry at school**. Where pupils are able to directly link the university laboratory experience to their school studies, there is more likely to have been such an impact, as this pupil explains: '*We were doing our NMR spectroscopy* [and] *since then some of the stuff that* [the lecturer] *said came up on the test so I remembered it and I hope I answered it right!*'. However, some pupils are not able to make a direct link between the visit and their school learning, seeing the university laboratory experience as quite distinct and unique. Pupils suggest that the university laboratory visit has only been a single day and covered only a single chemistry topic; thus in the overall scheme of their school careers, has been a relatively minor aspect of the knowledge delivery.

Teacher and manager views

During interviews with teachers, they too suggest that the activity provides the pupils with an **opportunity to develop their practical skills and use equipment they have not used before**, requiring a superior level of precision and accuracy. As one teacher comments: '*All I'd managed to do with our facilities was to get chlorophyll out of leaves, because that's all we've got. So for them to do something so complex was really a good experience for them*'. Teachers feel that the pupils' achievement in these challenging activities has given them a sense of confidence that they could study chemistry further if they wished. In addition, teachers identify that the pupils have been enthused and motivated by the experience to put more effort into their chemistry learning and achieve good grades (also as a result of seeing it as a more worthwhile and enjoyable subject). The strand manager also indicated that impacts on increased level of attainment were likely, given the emphasis of this type of intervention on curriculum-based and enhancing activities.

Awareness and understanding of HE, chemistry in HE and chemistry careers

The evaluation data suggests that young people's awareness and understanding of higher education, chemistry in higher education and chemistry careers have been positively impacted by their experiences of the Strand 4 project. Again, the initial questionnaire asked pupils to rate on a 1 to 5 scale the extent to which their experiences of chemistry activities and events have made a difference to their awareness in a number of areas. Their mean response ratings are presented in table 9.3 below.

Table 9.3: Impact ratings: Strand 4 pupil survey sample

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Awareness of higher education generally (e.g. what university is like)	2	7	28	46	14	3.6
Awareness of chemistry courses in higher education	3	20	32	31	14	3.3
Awareness of chemistry careers/what chemists do	3	19	34	40	2	3.2
N=95						

Source: NFER pupil survey, 2007-08
A total of 95 respondents gave a valid response to at least one of these items

Table 9.3 shows that pupils rated the impact of a university laboratory visit on their awareness of higher education generally on average as 3.6 (on a 1 to 5 scale). Sixty per cent of pupils rated the impact on their awareness of higher education generally with a 4 or 5 (indicating that the experience has made 'quite a lot' or 'a great deal' of difference). Pupils did not report as strong an impact on their awareness of chemistry courses in higher education and less still on their awareness of chemistry careers, giving these items mean ratings of 3.3 and 3.2 respectively and only 45 per cent and 42 per cent of pupils gave a 4 or 5 rating to each of these items.

Pupil views

Interviewed pupils are slightly more consistent in their identification of the positive effects of the university laboratory visit on their awareness of higher education and further chemistry study and careers, than the survey sample, with the majority indicating that they had been impacted in these ways. In particular, pupils highlight a greater understanding of chemistry careers and appreciation of what chemists actually do. The experience has increased their:

- **understanding of chemistry careers/what chemists do** – pupils feel the visits have shown them what chemists themselves do, but also the wide range of job opportunities available to a chemistry graduate. As one pupil comments: '*It's just being alerted to what you can do with chemistry, as opposed to just being a chemist, there is like loads of different jobs you can do with it'*.

- **understanding of higher education generally** – going to a campus, seeing the facilities and talking to undergraduates gives school pupils a good idea of university life. One explains: '*I thought it was really helpful for that, you don't often get to go to university and we weren't just in that room, we walked through seeing students working and general student life, what they actually do, it was useful to see.*' Additional data gathered from four schools who visited the University of Sheffield confirmed that the majority of pupils feel the experience has taught them about higher education and studying at university.
- **understanding of chemistry courses in HE** – from talking to lecturers, undergraduates, postgraduates, and seeing the facilities this has given the pupils an understanding as to what it would be like as an undergraduate chemist. Particular aspects of this experience appeal to the pupils, such as realising that chemistry study in higher education is practical, that students work independently and with advanced equipment and facilities, and that the experimental process can be very satisfying. However, some suggest that although they have seen students working, they did not find out enough information to really understand about courses.

Teacher and manager views

Teachers, laboratory managers and the strand manager (based on feedback from pupils and teachers) agree with the views of pupils, suggesting that the university laboratory experience gives pupils a taste of undergraduate chemistry study. Teachers identify several specific impacts on their pupils. These are outlined below.

- The experience has given the pupils an **insight into the practical application of chemistry**. One teacher comments that: '*It's made them more able to see* [chemistry] *in its context*', and another suggests the most salient impact of the university laboratory experience has been on pupils '*enthusiasm and their insight into what goes on in the laboratory and the sort of things that they can do and the facilities that there are available*'.
- The experience has given pupils an insight **into chemistry degrees**, as these teachers explain: 'It gave them a really good look at undergraduate chemistry and it allowed them to see what they would be doing' and 'They have come back with a very positive image of university science and of the facilities, that's quite clear from talking to them'.
- The experience is thought to enable pupils to make more informed decisions about further chemistry study and careers, giving them a greater **understanding of the possibilities and raising aspirations** both towards higher education and chemistry further study. One teacher explains: '*It's the atmosphere, it's the fume cupboards, it's all the people who are taking it seriously, it's doing the practical skills and it's opening their eyes to what's actually available to them because they are quite blinkered*'.

Attitudes and perceptions of chemistry

The Strand 4 project seems to have had a positive impact on pupils' attitudes and perceptions of chemistry.

The initial questionnaire asked pupils to rate the extent to which their experiences of chemistry activities and events have made a difference to their attitudes towards and perceptions of chemistry. Their responses are presented in Table 9.4.

Table 9.4: Impact ratings: Strand 4 pupil survey sample

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Enjoyment of chemistry in school	5	4	19	52	18	3.7
Understanding of relevance/usefulness of chemistry	4	12	28	40	14	3.5
Attitudes towards or perceptions of chemistry	6	12	36	37	8	3.3
N=95						

Source: NFER pupil survey, 2007-08
A total of 95 respondents gave a valid response to at least one of these items

As can be seen from the table above, pupils on average gave positive ratings on the 1 to 5 scale, to suggest that the university visits have made a difference to their enjoyment of chemistry, understanding of the relevance and usefulness of chemistry and attitudes towards and perceptions of chemistry. Seventy per cent of pupils rated the project with a 4 or 5 in terms of the difference it had made to their enjoyment of chemistry, making this the strongest single outcome of the project. The project has also had a positive impact on pupils' understanding of the relevance and usefulness of chemistry (54 per cent rated this item a 4 or 5) and their attitudes towards and perceptions of chemistry (45 per cent rated this item a 4 or 5).

Pupil views

Similarly, the majority of the pupils interviewed feel that the activities have made a difference to their:

- **enjoyment of chemistry** – for some, this is linked to a greater interest in the subject, and for others it is linked to enhanced understanding of chemistry and its practical applications. One pupil comments: '*Making* *paracetamol, you just take it, you don't really know how to make it, but we actually had to make it so it was just fascinating…*' Another pupil was a bit disappointed to be back at school after the visit, and wanted access to more opportunities in the same vein.

- **understanding about the relevance and usefulness of chemistry** – the visits demonstrate to pupils how the chemistry they are doing links to practical applications in the 'real world', as these pupils explain: '*It makes it seem that it has got a point and it's not just to pass exams and stuff like that*' and '*I always thought it was a useful subject to do but even more so now, seeing everyone in university and how important it must be to see everyone going there to study it*'.

Teacher and manager views

The teachers interviewed agree that the university laboratory experience makes a significant impact on pupils' interest in studying advanced chemistry and appreciation of the subject as a worthwhile pursuit. These teachers explain that: '*There were some pupils who did say that as a result of going on that day that they would be more inclined to study chemistry*' and '*I think it has an impact on their attitude and raising the bar a little bit in terms of their horizons as well'.*

Future intentions and participation in chemistry

The evaluation data suggests that the Widening Schools' Access to University Laboratories project has the capacity to influence pupils' future intentions and participation in chemistry. The initial questionnaire asked pupils to rate the extent of impact from the project on a series of items relating to their future intentions. Their mean responses are presented in Table 9.5.

Table 9.5: Impact ratings: Strand 4 pupil survey sample

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Future intentions (e.g. further study/career plans)	5	11	31	32	20	3.5
Future intentions to study chemistry	17	18	21	32	11	3.0
Future intentions to go to University/HE	20	13	24	31	11	3.0
Future intentions to take a career in chemistry	22	16	41	16	4	2.6
N=95						

Source: NFER pupil survey, 2007-08
A total of 94 respondents gave a valid response to at least one of these items

Table 9.5 shows that pupils' experiences of the Strand 4 project has had a positive effect on their future intentions towards further study and careers (mean rating 3.5). Fifty-two per cent of respondents rated this type of impact as a 4 or 5, indicating a strong positive impact for half of the sample. Forty-three per cent of pupils rated 'quite a lot' and 'a great deal' of impact on their future intentions to study chemistry as a result of their experiences of chemistry interventions. Although there appears to be less impact on young people's future intentions to choose a career in chemistry following the interventions, a fifth of pupils (20 per cent) report that chemistry interventions, including the university laboratory visit, have made a difference to their intention to take a career in chemistry (i.e. rated 4 and, occasionally, 5).

Pupil views

Qualitative discussions with pupils during interviews also indicate that the Strand 4 project is having a positive impact on at least some of the pupils' future intentions. Over half of the sample (13 out of 23) report that they are more likely to take chemistry further as a subject since their experiences of the university laboratory visit. A third of pupils interviewed report that they are more likely to choose a career in chemistry and go to university since the university laboratory visit (8 and 9 out of 23 respectively). For the remaining young people, the intervention tends to have made 'no change' to their future intentions, although, regarding decisions to go to university, this is often due to the fact that the pupils have decided to go to university anyway. The impacts identified are outlined below.

- **Impact on likelihood to take chemistry further as a subject** – the experience appears to inspire, promote and confirm pupils' interest in chemistry, as this pupil comments: '*I decided I wanted to do chemistry for A-level, because I knew I was doing GCSE and I knew what I would be doing at degree level and I thought it's getting much more interesting so I thought I'll take it for A-level*'. For science-interested pupils the experience helps them to decide which of the sciences to pursue further, though there is little evidence to suggest it can convert choices where plans and ideas are already in place regarding further study and careers.
- **Impact on likelihood to go to university/HE** – a third are more likely to go to university as the experience has reduced anxieties and convinced them that university will be worthwhile. As one comments: '[The visit] *helps to get an idea of what goes on and how it could be useful*'. A similar number feel the experience has not impacted on their decision, but most intended to go to university prior to the visit

- **Impact on likelihood to take chemistry further as a career** – a third feel the university laboratory experience has made them more likely to take chemistry as a career as a result of finding out more about what it would involve. However, often these pupils already have a strong interest in the area of science and chemistry but the university laboratory experience has helped them to choose between science related options and confirm potential decisions.
- Furthermore, eleven per cent of the pupil survey sample report that they **intend to take chemistry to degree level**, while 51 per cent only intend to take chemistry up to A2-level. However, in an open question to pupils about their future plans and career ideas, chemistry does not feature strongly, and less commonly than options such as medicine, dentistry and veterinary science.

Teacher and manager views

Additional evaluation data from pupils from four schools where pupils and teachers have visited the Sheffield schools' laboratory suggests relatively small but significant differences are being made to pupils' likeliness to consider going to university, studying chemistry and chemical sciences careers. Teachers, laboratory managers and the strand manager also report anecdotal evidence of increases in the uptake of GCSE triple award science and A-level chemistry, and feel that the university laboratory experience will make a positive contribution to this in the long term. These findings indicate that the project has the capacity to impact on young people's actual chemistry decision-making behaviour.

9.5.2 Outcomes for teachers

This section explores the outcomes of the strand on participating teachers. Teachers gave their views on what they thought of the university laboratory experience for themselves. Data are drawn from 5 teacher interviews and 3 teacher follow-up interviews as well as, where appropriate, information from the laboratory manager and strand manager interviews.

All teachers have enjoyed their visits to the university laboratories, claiming the experience enthuses, motivates and provides an opportunity for them to develop their relationships with the pupils. All teachers are keen to, or already have, used the university laboratory facilities again.

The teachers were asked to respond, on a scale of 1–5, to a series of questions to ascertain whether the activities had made any difference to their professional development, and to provide details. Four areas of impact were rated particularly highly by the teachers:

- the schools' **links with HEIs/industry/other schools** – teachers are benefiting from these contacts as a source of support and resource (e.g. work experience placements) and as a conduit for developing wider links with other departments of the university, as one teacher outlines: '*It's given me an in way to a variety of people at the university, up to date information, yes definitely'.* Both universities were working with existing school partners as well as new ones
- their **access to resources and materials** – through access to the laboratory itself and academic contacts from whom they have gained further resources and materials
- their **capacity to support and advise their pupils** regarding further chemistry study and careers – due to the greater contact and strengthened relationships with the local university, the teachers gain access to up-to-date study and careers information. This could prove to be very important given the lack of clear chemistry-related careers advice that has been demonstrated in the research literature
- the **profile of chemistry in the school** – university laboratory visits have been one of a number of other chemistry interventions and activities contributing to raising the profile of chemistry in school and positive perceptions of the subject.
-

Other areas of impact that were rated reasonably highly, although not as strongly as the above, were:

- developments in their own **chemistry teaching** – teachers have acquired some new ideas, including variations on chemistry techniques, and are motivated to reflect on and develop their teaching in particular ways, as this teacher describes: '*It reminded me of my degree days. It reminded me of what equipment is available and the different techniques that we don't use in school that I could mention during my lessons*'. Extensive impacts in this regard are inhibited by school factors, such as limited time, resources (including, technician support) and equipment
- their own **career development and professional development** – through the forging of links with local universities, expanding their network base, which was felt to be a resource transferable to other posts. In addition, experience in organising extra-curricular trips was felt to be a useful skill to develop and maintain
- **knowledge of chemistry/chemical science** – although all the teachers interviewed were experienced chemistry specialists, some feel the experience of visiting a university laboratory has served to refresh and

remind them of their own training, highlighting aspects of practical chemistry that they had forgotten and were therefore perhaps not using. The experience is potentially impacting more on less experienced teachers.

Three further areas were probed, but the teachers generally rated these impacts lower than those above:

- awareness of **chemistry careers** – through seeing chemists work, and informal discussions with staff about university entrance requirements. Several teachers did not feel more aware of chemistry careers
- teaching of **practical lessons/experiments** – there has been limited impact due to the teachers' level of experience and school factors (see above), although some ideas for practical teaching have been absorbed. The teachers feel that the university laboratory visit has enabled them to better deliver the practical chemistry curriculum, offering pupils a quality of practical experience that they are unable to deliver in school
- **confidence to teach chemistry** – there was no significant impact on confidence as all teachers were very experienced.

The laboratory managers interviewed also suggested that there may be **CPD impacts** on the teachers who accompany pupils to the university laboratory as a result of establishing the relationship with the HEI and the dialogue taking place during the events. It has also been pointed out, as this following comment illustrates, that although the teachers in the case-study sample are experienced chemistry specialists, pupils may also be accompanied by non-specialists, inexperienced and new teachers and technicians, thus providing greater scope for impacts.

> *We don't just talk to the pupils when we're doing this, we seem to be doing some partial training of their accompanying teachers, whether they're chemists, biologists or physicists, or student teachers or chemistry technicians – they're asking questions, we're giving them information on things that they're taking out and, we're being told, using back in their schools.*

9.5.3 Outcomes for others

Positive impacts of Strand 4 activities are also reported on the universities involved in terms of their profile and recruitment to undergraduate chemical science courses. Indeed, in open survey responses 11 pupils specified that they intend to go to the university they have visited as part of their future study and career plans. Accordingly, the project is developing into a worthwhile project for universities to support, with benefits for both parties – schools and universities. In addition, there is scope for the personnel involved in running the schools laboratory activities to benefit from the experience in terms of enjoyment of working with the school pupils and professional development. It would be interesting to explore further the potential impacts for the undergraduate and postgraduate students involved in supporting the school pupils as part of this intervention (although it is important to bear in mind that at both universities the Strand 4 project constitutes just one element of existing, extensive outreach programmes). Finally, there has also been considerable sharing with other HEIs outside of the project regarding the experiences of the project, key learning and information regarding how to effectively operate such a scheme. This sharing may impact on universities in relation to their opening up of their laboratories to local schools. The sharing has been facilitated by a network of school teacher fellows across various institutions.

That local authorities were becoming increasingly convinced of the value of this kind of outreach and extra-curricular activity was also discussed. However, it was recognised that local authorities had only limited capacity to encourage participation through endorsement due to school-level autonomy. Conversely, with initiative overload, some local authorities might encourage participation in certain programmes (for example, those that have demonstrable impact on pupil attainment and school improvement) and discourage participation in others. Staff in universities considering developing a schools lab, such as those in Bristol and Sheffield, would need to be aware of the context of their local schools and local authorities in terms of potential engagement in such laboratory activity.

9.5.4 Outcomes summary

Table 9.6 summarises the types and prevalence of various impacts from pupils' experiences of visiting a university laboratory.

Table 9.6: Overall rank order of impacts: Strand 4

Statement	% rating 1	% rating 2	% rating 3	% rating 4	% rating 5	Mean rating
Enjoyment of chemistry in school	5	4	19	52	18	3.7
Chemistry knowledge and skills	0	11	23	50	15	3.7
Awareness of Higher Education	2	7	28	46	14	3.6
How well you're doing in chemistry in school	5	10	26	48	8	3.5
Understanding of relevance/usefulness of chemistry	4	12	28	40	14	3.5
Future intentions (e.g. further study/career plans)	5	11	31	32	20	3.5
Attitudes towards or perceptions of chemistry	6	12	36	37	8	3.3
Awareness of chemistry in HE	3	20	32	31	14	3.3
Awareness of chemistry careers	3	19	34	40	2	3.2
Future intentions to study chemistry	17	18	21	32	11	3.0
Future intentions to go to University/HE	20	13	24	31	11	3.0
Future intentions to take a career in chemistry	22	16	41	16	4	2.6
N=95						

Source: NFER pupil survey, 2007-08
A total of 95 respondents gave a valid response to at least one of these items

There are clearly numerous **positive outcomes for pupils** from their experience of the Strand 4 project. The strongest impacts of this strand appear to be on:

- pupils' enjoyment of chemistry
- pupils' chemistry knowledge and skills
- pupils' awareness of higher education.

Where these impacts are strong, it seems that the Widening Schools' Access to University Laboratories project has the **capacity to affect young people's behaviours and decisions around further chemistry study and careers**. For those with an existing interest in chemistry and the sciences, the experience can help their decision making around whether or not to take it further or what aspect of chemistry to choose.

The strand also has **CPD impacts on the teachers** involved, particularly in terms of enhancing their:

- links with HEIs/industry/other schools
- access to resources
- capacity to support and advise pupils regarding further chemistry study and careers.

The project has also contributed to **impacts on universities and the availability and quality of chemistry outreach**, including:

- positive impacts on the universities involved in terms of their profile and recruitment to undergraduate chemical science courses and experience of providing innovative outreach activities to schools
- positive impacts on university personnel involved in running the schools laboratory activities in terms of enjoyment of working with the school pupils and professional development (e.g. for undergraduates and postgraduates)
- positive impacts for other HEIs regarding the experiences of the project, key learning and information regarding how to effectively operate such a scheme as a result of sharing good practice. This sharing may impact on universities in relation to the availability of school laboratory-based interventions. The sharing has been facilitated by a network of school teacher fellows across various institutions.

The limitations on schools' regular use of university laboratories with the same cohort of pupils may undermine the strength of impact possible from the initiative. However, all pupils within this evaluation sample only experienced a single visit to a university laboratory, suggesting there may be significant positive impacts from such isolated interventions. Thus, where schools are able to bring large cohorts of different pupils (as opposed to make repeated visits with the same pupils), there is potential for the experience to spark and deepen interests in chemistry across a greater proportion of the school population.

9.6 What works and lessons learnt

According to the evaluation data, aspects of the programme that are working particularly well are:

- the emphasis on **practical work/experimentation** (the importance of opportunities for hands-on learning and development of practical, technical skills pitched at a level slightly above that which would be practised in school)
- school **teaching experience of the deliverers** (quality of delivery e.g. knowledge of how to engage school age pupils, pitched at appropriate level)
- **support from undergraduates** and post graduate students (providing relevant role models and accessible sources of information as well as effective ratios of staff to pupils) (particularly so in *Bristol*, where post graduates are available on a regular basis and are paid)
- **flexibility and tailored activities** (e.g. to age group, level, syllabus. This is particularly so in *Sheffield*, where activities are planned in conjunction and discussion with the school teachers)
- the **quality of the facilities and equipment** (provides experience of a 'state-of-the-art', 'real laboratory' for school pupils and 'best practice' for teachers)
- the **university experience** (pupils being treated differently/maturely, being excited by the level of work, working in a university environment)
- the **relevance** of the sessions and emphasis on **curriculum-enhancement** (e.g. to ensure the experience contributes to teaching and extending teaching, perhaps delivering an aspect of the curriculum in a practical way that the school teacher may not be able to teach in school)
- **advanced warning of activities** – allowing lead in time to enable schools to plan and prepare for the visit
- opportunity for **teacher participation and involvement** was appreciated by the teachers as it gave them chance to work with their pupils in a different, and more relaxed environment, was enjoyable and also enabled them to pick up ideas and information
- **combinations of activities** – day-long events comprising varied activities such as practical work, lectures and talks, tour of the university, were found by both projects to be particularly successful
- **partnership working** – between HEIs (including those directly involved and wider), which has been facilitated by a developing network of school teacher fellows.

Challenges and barriers

Teachers identified a range of challenges relating to using the laboratories in Bristol and Sheffield. These are outline below.

- **Capacity of the laboratories** – in *Sheffield* the limited capacity of the laboratory has been an issue for one school. In order to use the facility the teacher has to be selective about which pupils can experience the intervention or make repeated visits with different groups, creating organisational challenges. Although the laboratory at *Bristol* has a far greater capacity, it still has to be staffed at an appropriate ratio.

- **Transparency of costs involved** – it is important that schools know how long their use of the laboratories will be funded for, and what the associated costs would be without the funding. They feel that charges might inhibit their ability to use the laboratories. Some schools say that a charge has already inhibited their capacity to access the facilities. As noted in section 9.4, funding arrangements will be important for the sustainability of the laboratories. Universities considering developing such laboratories will need to address funding and charging arrangements.
- **Restrictions on how often they could take pupils out of school** – teachers are only able to take individual pupils to the laboratories once per year due to school restrictions regarding removing them from other subjects and study. Therefore, although there are repeated bookings by individual schools, they involve different groups of pupils. There are also issues associated with teachers arranging time out of school.
- **Transport costs for schools** – the costs of transporting pupils by coach or public transport to the university laboratory facility is felt to be considerable and may be a threat to schools using the facility.
- **Teachers' scepticism of the relevance of activities** – all teachers consulted as part of the evaluation have found their experience of the university lab visit to be relevant to the chemistry curriculum they are teaching. However, they suggest that it is common among teachers to be sceptical about the worth of some events and activities and that this may be a barrier for new schools.
- **Organisational considerations** – teachers must undertake considerable organisation in arranging visits, such as risk assessment, parental consent, transport and funding.

Challenges were also identified for the universities running the laboratory facilities, though in most cases these had been surmountable. These are outlined below.

- **Staffing** – a significant degree of staffing support is required to run the university laboratory facilities for schools' use, for example, to support the delivery of the sessions, and to ensure technical preparation and maintenance. Ideally, administrative support to organise school bookings and enquiries is also needed.
- **Short notice cancellations** by schools – this prohibits the facility being used by other schools due to the advanced organisation and preparation schools require to visit the facility in terms of transport, staff cover, parental consent and risk assessment. Issues of timetabling, cover and coordination of outreach activities were identified as challenges for schools. Mediating these issues was felt to rely upon ensuring the

availability of the laboratory facilities long term, so that schools could incorporate them into their planning well in advance.

- **Engaging hard to reach schools** – this remains a challenge and despite considerable efforts to attract and promote the facility to all schools, some schools remain unengaged.
- **Funding** – the onset of full economic costing models in universities, whereby they will have to recover overheads to support the costs of outreach work, are expected to impact on the sustainability and funding of such projects (and there are issues around establishing the actual costs of such activities). Ensuring a balance between supporting the projects while ensuring costs are recovered as far as possible, had been challenging.

The two models compared

The similarities and differences between the two models adopted to trial Widening Schools' Access to University Laboratories' at the Universities of Sheffield and Bristol have been drawn out throughout the chapter where appropriate. The models have produced equally positive outcomes for school pupils and their teachers, and, both face similar issues and challenges (e.g. staffing, engaging harder to reach schools). Here we will attempt to present a summary of the key features and key issues for each model in order to provide a useful resource to other HEIs considering such an intervention. Further comparison of the two models will be evaluated in the extension phase.

Table 9.7: Comparison of the Strand 4 models

	Sheffield	Bristol
Advantages	• Flexibility in availability to schools • Schools' sense of ownership of the facility	• Large capacity (200 students) • Use of existing facilities
Disadvantages	• Initial expense of creating dedicated laboratory • Limited capacity (15 students)	• Limited availability to schools • Large pupil groups require significant staff support resource/ratio

Suggested improvements and changes

The case study pupils have not mentioned any significant changes they want to make to the activities they have experienced. They feel the activities are enjoyable and set at an appropriate level. Several pupils comment that they want to go for longer (especially if they have only been for a half day visit) and make repeated visits to the laboratory. There are also suggestions for having a greater proportion of practical work as part of the visit, and more opportunities to talk to undergraduates and find out what they are doing. Isolated comments request minor changes to the activities and experiments e.g. to be more exciting, more relevant to school learning.

Similarly, the teachers do not want to make any changes to the activities they have experienced at the university laboratories. One comment advocated the need for even greater links to be made between the activity and real world chemistry e.g. brief talks on the chemistry research underway at the universities.

9.7 Additionality

Case study schools involved in the evaluation report that their capacity to use the university laboratory facilities would be curtailed if there were a charge associated with the activities. Hence, it seems quite possible that without the CFOF funding these teachers and pupils would not have visited university laboratories and benefited in the ways discussed above. In particular, the funding is enabling teachers to better deliver aspects of the school chemistry curriculum (providing a quality of practical experience that they are often unable to provide in school) and is allowing pupils to gain a taste of 'real chemistry' beyond the school experience.

It is acknowledged that both the Universities of Bristol and Sheffield were well established in terms of their outreach provision prior to the project. However, the CFOF funding had enabled the development of a distinctive emphasis in HE outreach practices, with greater focus on curriculum support, as opposed to the more traditional focus on raising aspirations. The CFOF funding has enabled the universities to trial and innovate with new activities and new approaches to running existing activities. The project also enabled exploration of the problems associated with school and university partnerships, thus helping them to work with a broader range of schools. The universities have been given an opportunity to be more creative and innovative, thus enhancing the capacity for longer term and wider ranging impacts from their outreach activities.

9.8 Next steps

Funding has been made available for an extension year of Strand 4 during 2008-09 at the same level pro-rata as the original funding.

Arrangements are in place at both the Bristol and Sheffield projects to staff and run the laboratory facilities in the following academic year. Both projects seek to expand the repertoire of tried and tested practical activities, as well as further develop programmes that have been piloted with success in the initial year, with a continued focus on curriculum enhancement (e.g. university experience days and summer schools, 50/50 laboratory and spectroscopy sessions). In addition, both sites aim to maintain and extend their roles in sharing good practice regarding Widening Schools' Access to University Laboratories with other universities and continue to develop partnership working with industrial sponsors in order to further secure the sustainability of the scheme.

Plans are being discussed in terms of ensuring the sustainability of the scheme for the future, including resolving funding issues and continuing to develop links with schools, in order to build schools' confidence in the longevity of the activities and, therefore, sustained and planned usage. Ideas were also explored in terms of alleviating some of the administrative demands of the project and ensuring greater efficiencies, including development of online booking systems.

Teachers request that the new found links with the universities could be developed in terms of providing extended opportunities for young people inspired and motivated by the laboratory experience to further develop their interests (e.g. opportunities for work placements). Equally, university personnel recommend the value of being able to provide the school pupils with free chemistry careers resources (supplied by organisations such as RSC) in order to improve the continuity of support available to interested young people.

10. Outcomes and impacts: an overview of NFER pupil questionnaire data (Strand 1 and Strand 4)

This section considers the pupil survey dataset from the surveys conducted in Strands 1 and 4 by NFER. The pupil surveys for Strand 1 and Strand 4 used the same questionnaire instrument. Whilst, the findings for each strand are dealt with in separate relevant sections of this report, this section examines the key overarching findings to emerge from the whole pupil survey dataset.

In particular, we have probed the whole dataset to see whether any of the following make a difference to the extent or nature of impacts reported:

- extent of participation in (a range of) chemistry events and activities
- gender
- age group (key stage 4, i.e. years 10 and 11, and key stage 5, i.e. years 12 and 13).

In addition, the key similarities and differences in impacts for Strand 1 participants compared with those for Strand 4 are summarised.

10.1 Key findings

- The survey findings highlight the importance of **enabling pupils to experience a number and range of different chemistry interventions**. Pupils who experience a number and range of chemistry interventions and activities, have **more positive attitudes towards chemistry** and **report stronger impacts on their attitudes towards chemistry** and **their future intentions to take chemistry further as a subject or career** than those who have experienced only one activity.
- The qualitative findings across Strands 1 and 4 also suggest that series of chemistry interventions, providing **multiple experiences and continuity** may be particularly impactful. The development of **guidance for teachers** to plan for, and follow up interventions with their pupils, would be beneficial, and would contribute to a sense of continuity and 'build-on' in pupils' learning.
- There is a need to **enhance the impacts of chemistry activities for female pupils specifically**. **Female pupils have less positive attitudes towards chemistry** and are less positive in their **ratings of impacts** than male pupils. **Females also report they find chemistry hard**.
- **Key stage 4 pupils gain slightly more** from experiencing chemistry

interventions and activities compared with their key stage 5 peers. They report more impacts on their enjoyment of chemistry, future intentions (including to study chemistry further) and how well they're doing in chemistry.

- However, **key stage 5 pupils are slightly more likely than the key stage 4 students to intend to take a career in chemistry**. This perhaps reflects the closer proximity of the key stage 5 pupils to such career-thinking and decision making.

10.2 About the pupil survey sample

A questionnaire survey was conducted with **187** pupils from eight schools who were involved in CFOF Strand 1 and 4 activities. The survey sample comprised **roughly equal proportions of males and females** (53 per cent males and 45 per cent females) and included pupils from **year groups 10–13** (though with lesser representation from year 12s). Overall, the pupils in the sample can be categorised as **reasonably high achievers** (usually reporting predicted or achieved grades of A–C in science subjects), and most of the key stage 4 sample were studying triple award science.

10.3 Extent of participation in (a range of) chemistry events and activities: does this make a difference to impacts?

Pupils' attitudes to a series of statements are displayed in Table 10.1, categorised by the number of different types of activities they report experiencing in their school careers (i.e. the extent of their participation in chemistry events and activities). Pupils' reports of impacts from participating in chemistry events and activities are displayed in Table 10.2, again, categorised by the extent of their participation in a range of activities.

Table 10.1 Attitudes to chemistry by no. of types of activities experienced

Statement (Q3)	1* type of activity - proportion rating 4/5	2-3 types of activity – proportion rating 4/5	4 or more types of activity – proportion rating 4/5
I am not doing/am doing well in chemistry	48	61	66
Do not enjoy/enjoy chemistry	64	76	77
Chemistry is hard/easy	16	21	27
Chemistry is not useful/useful for everyday life	28	55	65
Chemistry is not useful/is useful for jobs/careers	68	82	84
I do not like/do like the way chemistry is taught	72	59	70
I don't know/do know a lot about what chemists do	40	38	53
I am not/am aware of a range of chemistry careers	32	44	57
I don't know/do know a lot about higher education	64	67	67
I do not feel/do feel prepared for higher education	76	65	65
I do not intend/do intend to go to university	88	91	88
There aren't/are interesting/exciting chemistry careers	40	62	62
I do not/do intend to take chemistry further as a subject	28	35	49
I do not intend/do intend to take chemistry for a job/career	20	32	21
N=187			

Source: NFER pupil survey, 2007–08
** category includes six non-responses to this question, however, according to information provided by class teachers, all pupils taking part in the survey had been involved in at least one chemistry enrichment activity.*

- As seen in Table 10.1, **pupils who have experienced two to three, or four or more different types** of chemistry interventions and activities, tend to have **more positive attitudes towards chemistry** than those who have experienced only one activity.

- As seen in Table 10.2, pupils who have experienced **more than one type** of chemistry event and activity also give higher positive ratings in relation to impacts on their **attitudes towards chemistry**, and **their future intentions to take chemistry further as a subject or career**.

Table 10.2 Impacts from chemistry events and activities by no. of types of activities experienced

Statement (Q8) – impact of activities	1* type of activity - proportion rating 4/5	2-3 types of activity – proportion rating 4/5	4 or more types of activity – proportion rating 4/5
Attitudes towards chemistry	24	41	50
Future intentions to go to HE	40	47	42
Future intentions to study chemistry	24	30	42
Future intentions to take a career in chemistry	12	20	22
N=187			

Source: NFER pupil survey, 2007–08
** category includes six non-responses to this question, however, according to information provided by class teachers, all pupils taking part in the survey had been involved in at least one chemistry enrichment activity.*

Caution should be exercised in drawing conclusions about causal relationships from these findings. It is not clear whether such positivity is due to pupils' experiencing a greater range of chemistry activities or whether those pupils who are positive about chemistry choose to participate in more activities. However, these results are suggestive of a positive relationship between the range of activities young people experience and positive attitudes and intentions towards chemistry. **The greater range of interventions pupils experience, the more positive they tend to report being about chemistry**.

A similar pattern of findings, as those discussed above, are also found amongst the follow-up survey sub-sample, whereby those experiencing particularly four or more different types of chemistry interventions are more likely to report positive attitudes towards chemistry and positive impacts from chemistry interventions.

This finding highlights the importance of **enabling pupils to experience a range of different chemistry interventions**, targeted towards different elements of chemistry experience and learning and delivered in different contexts. It also suggests that a **series** of chemistry interventions, providing **multiple experiences and continuity**, may be particularly impactful.

10.4 Gender: does this make a difference to impacts?

The survey findings suggest that, in general, **male pupils have more positive attitudes towards chemistry than female pupils**. Compared with females, **males:**

- give higher positive ratings to the statement that they are **doing well in chemistry** (68 per cent of males rate this statement positively with a 4 or 5, compared to 54 per cent of females)
- give higher positive ratings to the statement that they **intend to take chemistry further** as a subject (48 per cent compared to 30 percent of females)
- more often indicate the intention to take **chemistry beyond post-18 level**, although across both genders this intention is relatively rare (14 per cent of males report that they intend to take chemistry to degree or higher degree level, compared to eight per cent of females)
- are more **undecided** as to the highest level they intend to take chemistry (25 and 13 per cent of males and females respectively responded in this way) (indeed, **more females were committed to the decision not to take chemistry further)**
- are more positive than females in their ratings of the impacts from the chemistry activities and events they have experienced, for instance on their:
  - **chemistry knowledge and skills** (63 per cent and 45 per cent respectively)
  - **awareness of chemistry careers** (47 per cent and 29 per cent respectively)
  - **enjoyment of chemistry in school** (65 per cent and 47 per cent respectively)
  - ratings of **how well they were doing in chemistry** (60 per cent and 34 per cent respectively)
  - **intentions to study chemistry further** (44 per cent and 24 per cent respectively)
- rate their intention to take a career in chemistry only marginally higher than females (22 and 18 per cent respectively), suggesting that their increased positivity towards chemistry does not translate into decisions for further participation in equal proportions.

The above findings set out the key differences by gender, by presenting the findings for males. However, **for females**, a key finding is that a relatively high minority report that **they find chemistry hard**, and more so than male pupils (45 per cent compared to 22 percent of males).

Although the survey findings overall suggest that CFOF activities are having positive impacts on both male and female pupils, analysis of these impacts by gender indicates that there is a need to **enhance the impacts of chemistry activities on female pupils specifically**.

10.5 Age group: does this make a difference to impacts?

For analysis purposes, the ages of responding pupils were grouped into those pupils at key stage 4 (i.e. years 10 and 11, age 14–16), and those at key stage 5 (i.e. years 12 and 13, age 16–18). Analysis reveals some key differences by age group. Compared with their peers in key stage 5, key stage 4 pupils are:

- **more likely** to rate that they are **doing well in chemistry** (75 and 45 per cent of key stage 4 and key stage 5 pupils respectively feel they are doing well in chemistry)
- **less likely** to report that they **find chemistry hard** (17 and 53 per cent respectively report that chemistry is hard, rating 1 and 2).

These results are perhaps a reflection of the harder level of study associated with A-level chemistry and/or pupils more critical awareness of their abilities at post-16 level (i.e. key stage 5). In addition, perhaps reflecting their stage of study, compared with their peers in key stage 4, key stage 5 pupils are:

- more likely to intend to take chemistry for a career and intend to go to university
- **more confident** about their **knowledge of higher education**, perhaps highlighting their closer proximity to such decisions.

Further analysis suggests that key stage 4 pupils are slightly more likely than their key stage 5 counterparts to rate stronger impacts from the chemistry interventions and activities that they have been involved with. Table 10.3 compares the two age groups' responses to the impact statements.

Compared with their key stage 5 peers, **key stage 4 pupils report more impacts on their enjoyment of chemistry, future intentions (including to study chemistry further) and how well they're doing in chemistry**. This finding indicates that key stage 4 pupils may stand to gain slightly more from experiencing chemistry interventions and activities.

However, **key stage 5 pupils are slightly more likely than the key stage 4 pupils to intend to take a career in chemistry**. This perhaps reflects the closer proximity of the key stage 5 pupils to such career-thinking and decision making. Indeed, **key stage 4 pupils are far more likely to say that they are undecided** as to the highest level they intended to take chemistry (31 and 4 per cent respectively).

Table 10.3 Impacts from chemistry events and activities by age group (shown in a rank order by mean rating at key stage 4, followed by mean rating at key stage 5)

	Year 10-11		Year 12-13	
Statement	**% rating 4/5**	**Mean rating**	**% rating 4/5**	**Mean rating**
Awareness of higher education	63	3.7	56	3.6
Enjoyment of chemistry in school	64	3.7	48	3.4
Future intentions (e.g. further study/career plans)	59	3.7	49	3.4
Chemistry knowledge and skills	57	3.6	51	3.4
Understanding of relevance/usefulness of chemistry	54	3.6	51	3.4
How well you're doing in chemistry in school	59	3.6	33	3.0
Attitudes towards or perceptions of chemistry	43	3.3	43	3.3
Future intentions to go to university/higher education	47	3.2	40	3.1
Awareness of chemistry careers	36	3.1	42	3.2
Awareness of chemistry in higher education	35	3.0	37	3.2
Future intentions to study chemistry	40	3.0	30	2.8
Future intentions to take a career in chemistry	15	2.6	25	2.6
N=187				

Source: NFER pupil survey, 2007–08

10.6 Strand 1 and Strand 4 activities: does the strand make a difference to impacts?

Pupils' views of the impacts of Strand 1 and 4 activities are compared in Table 10.4, which displays their mean ratings and percentage of 4 or 5 ratings (denoting a strong positive impact), in response to each impact statement.

Table 10.4: Impact ratings: comparing Strand 1 and 4 (shown in a rank order by mean rating in Strand 1, followed by mean rating in Strand 4)

	Strand 1		Strand 4	
Statement	**% rating 4/5**	**Mean rating**	**% rating 4/5**	**Mean rating**
Awareness of higher education generally (e.g. what university is like)	59	3.7	60	3.6
Future intentions (e.g. further study/career plans)	56	3.6	52	3.5
Understanding of relevance/usefulness of chemistry	51	3.5	53	3.5
Chemistry knowledge and skills	46	3.4	64	3.7
Enjoyment of chemistry in school	44	3.3	70	3.7
Attitudes towards or perceptions of chemistry	43	3.3	45	3.3
How well you're doing in chemistry in school	40	3.2	57	3.5
Future intentions to go to university/higher education	43	3.2	41	3.0
Awareness of chemistry careers/what chemists do	37	3.1	42	3.2
Awareness of chemistry courses in higher education	31	3.0	44	3.3
Future intentions to study chemistry	30	2.8	42	3.0
Future intentions to take a career in chemistry	22	2.6	20	2.6
N=187				

Source: NFER pupil survey, 2007–08

Table 10.4 shows that pupils experiencing Strand 4 activities are more likely to rate strong impacts in a number of areas. Pupils' ratings suggest that compared with Strand 1 activity, **Strand 4** (visiting university laboratories) **has more impact on their**:

- chemistry knowledge and skills
- ratings of how well they're doing in chemistry at school
- awareness of chemistry courses in higher education
- enjoyment of chemistry in school
- future intentions towards studying chemistry, than the Strand 1 activities.

However, **pupils rate impacts from both strands equally in terms of benefits to their**:

- awareness of higher education
- awareness of chemistry careers
- understanding of the relevance and usefulness of chemistry
- perceptions of chemistry
- future intentions to go to university
- future intentions to take a career in chemistry.

In interpreting these results it is critical to be aware of the potentially **different types of schools and pupils each of the projects engages**. Strand 1 specifically targets Aimhigher schools (in order to encourage participation in higher education, especially amongst young people from families with no history of participation), while Strand 4 does not have such a specific targeting strategy and engages with those schools that volunteer to participate in these science enrichment activities. In addition, Strand 4 tends to involve AS or A-level students (and triple award key stage 4 pupils) who are likely to already have a strong interest in science (and possible in pursuing science). Strand 4 may thus provide a more intensive experience that is particularly successful with pupils who already have an enthusiasm for chemistry. In contrast, Strand 1 may have the potential for sparking such enthusiasm (although impacts on enjoyment of chemistry ratings are not as strong as those in Strand 4) and broadening young people's views of chemistry (see relevance ratings) and HE more broadly (as suggested by the data).

Accordingly, the **relative positions** of the pupils prior to the chemistry interventions and activities may not have been equal. **Thus it may be necessary to measure the extent to which each project moves pupils' perceptions along the scale towards positivity**. Change over time is considered within the relevant report section on each strand.

11. Overarching findings, concluding comments and recommendations

This section draws together the findings emerging across all four strands, and considers implications for the future development of CFOF and the subsequent STEM programme of activity.

11.1 How effectively has CFOF been managed?

CFOF has been well managed by the RSC and their partners. A particular area of success has been the way that programme management has encouraged **effective sharing and dissemination of learning and good practice**. The sharing has included what is working well, and, importantly, what is proving difficult or challenging. A spirit of collaboration and openness has been engendered throughout the whole management of CFOF, **particularly within strands**, and from operational management level to Project Advisory and Steering Groups.

In addition, there is evidence of collaboration **between strands** particularly where **key conduits** exist – such as key personnel (some of the teacher fellows have been instrumental in this), institutions involved in a number of strands, and through the Strand 3 gathering days where representatives from other strands have also been present. A focus on **greater networking between the strands** may help to share and disseminate learning and good practice further and achieve an even more integrated programme.

11.2 What are the impacts and outcomes?

For school pupils

The evaluation data suggests that CFOF has resulted in positive impacts on pupils, particularly on their **chemistry knowledge and practical skills**, **awareness of higher education**, **understanding of the relevance of chemistry**, and their **enjoyment** of chemistry. Through participation in CFOF enrichment and enhancement activities, pupils have learned about how chemistry is used and applied in 'real' life and have a greater understanding of the possibilities associated with the subject, raising their aspirations in relation to chemistry. For an **encouraging minority**, the activities do seem to affect their **future intentions** towards studying chemistry further and choosing chemistry as a career.

However, **greater emphasis may still be needed in CFOF enrichment and enhancement activities on chemistry careers** and the various routes into the discipline, as more modest impacts were evidenced in terms of pupils' understandings of chemistry courses in HE and chemistry careers.

The survey findings highlight the importance of enabling pupils to experience a **number and range of different chemistry interventions**. Pupils who experience a number and range of chemistry interventions and activities report stronger impacts on their attitudes towards chemistry and their future intentions to take chemistry further as a subject or career than those who have experienced only one activity.

Consideration may be needed as to how to **strengthen the impacts of CFOF activities on female pupils**, who generally report less prevalent impacts. The evaluation data also provides support for the targeting of CFOF activities towards younger age groups, as impacts tend to be slightly stronger for key stage 4 pupils (i.e. years 10 and 11), than key stage 5 pupils (i.e. years 12 and 13) who have, to a greater extent, made their future study and career decisions.

For undergraduates

Hard data is available to suggest that some CFOF activities have resulted in **improved attainment** for undergraduate chemistry students, due to interventions that have targeted and developed their knowledge and practical skills. This is the case in Strand 3.1, although not necessarily the case for context-based and problem-based learning (CBL/PBL) approaches in Strand 3.2. Improved attainment is not necessarily a key driver for undertaking CBL/PBL. Rather, the development of important transferable and employability skills and understanding of chemistry in context underlies CBL/PBL, and outcomes around these are demonstrated by Strand 3.2.

There is also evidence that CFOF activities are having positive impacts on the **retention of chemistry undergraduates**, due to a smoother transition from school to university aided by curriculum and pastoral support interventions targeted at first year students.

Undergraduates have also gained softer skills though their participation in the CFOF activities, including **transferable skills** in such areas as group work, presentation, independent learning, report writing and critical thinking – all important and desired 'employability' skills. They have expressed increased **motivation and interest in chemistry**.

For teachers and schools

Teachers involved in CFOF have benefited particularly in terms of the development of greater and **improved links and relationships between schools and universities** as well as **enhanced access to resources**. Teacher involvement in CFOF also impacts positively on teachers' **capacity to support and advise pupils** in relation to chemistry further study and careers, providing greater insights to chemistry in higher education and relevant contacts beyond the school phase. Teachers have also gained **new ideas** and resources from their participation in CFOF activities to aid their chemistry teaching and practice.

Schools' involvement in CFOF has resulted in a positive impact on the **profile of chemistry** and science in their school. Impacts on teachers from participation in CFOF may be stronger for those teachers who have less experience and/or are seeking to enhance their chemistry knowledge and practice or develop their departments. Senior management staff in schools should consider **which staff might best benefit** from these professional development opportunities.

HEI staff and institutions

Across the strands of CFOF, considerable positive outcomes have been reported for universities and university staff. In particular, university personnel have acquired an **enhanced understanding of school curricula, practices and student capabilities**, which in turn help them to **improve the delivery and effectiveness of their undergraduate teaching and outreach activities**.

Other benefits for universities include broader and stronger **relationships with schools**, **student recruitment and retention**, and professional development opportunities for staff. There has also been **increased partnership working and collegiality** in the sharing of knowledge and experience between institutions, e.g. school to university, and university to university.

11.3 What works well?

For school pupils

Activities work well for pupils when they **balance practical** work with theory, include **hands-on** and **collaborative** work, and are **relevant** to chemistry at work and chemistry in everyday life. It is the quality of the activity and experience that is rated (e.g. the **equipment**, help from undergraduates), rather than necessarily its location (although for some pupils, being in a university environment is important).

For undergraduates

Activities work well for undergraduates when they provide **support** in two key areas: i) in their **chemistry learning**, this includes through innovative curriculum and support materials, group work, and directing teaching and learning at student needs; and ii) **transition**, including through new induction programmes and facilitated opportunities to get to know each other in their new environment.

For teachers and HEI staff

Across the strands, activities work well when there is **teacher involvement** such that they gain ideas for the classroom, and resources for future use. Teachers appreciate activities that are **flexible and tailored** to schools' needs. Again, the quality of equipment and facilities are rated highly.

Relationships and links between teachers and HEI staff are best forged through **face-to-face** activity and in a **culture of openness**. Both formal and informal approaches work well when both parties learn from each other. For example, **demonstrating or modelling** new approaches works well in curriculum development and sharing of particular practice. The **informal exchange of ideas** through an e-mail network engages teachers.

As a theme across all activities, and for all participants, **adequate preparation** prior to activities being delivered is important. Examples that have worked well include preparation time for teachers in Strand 1 prior to activities, and the use of pre-induction materials in Strand 3.1.

Participation in CFOF by teachers and HEI staff seems to work best when they have **dedicated time** for the planning and delivery of activities.

What are the challenges?

A number of challenges have been experienced across the strands. Some have been addressed as the programme has developed. However, to aid the continued development of CFOF, the challenges highlighted here should be further considered:

- the **timing and timetabling** of enrichment and enhancement events for pupils/students – as this has an impact on attendance
- the need for adequate **lead-in time**/preparation time prior to the delivery of activities – e.g. for schools to prepare for a university visit, and for academics to prepare to CBL/PBL teaching approaches, for example in Strand 3.2
- the need for a **manageable workload** particularly for some key people – e.g. regional coordinators, certain academics, part-time staff
- engaging other HEI and teaching staff who are not first-hand participants in CFOF – i.e. **spreading the value** of CFOF to a range of other colleagues and institutions who are not involved in the programme
- **moving beyond one-off** activities and experiences for pupils, particularly within Strands 1 and 4
- **targeting schools and participants** to further meet the target groups for CFOF as a whole, in particular ‘widening the net’ to engage schools who would not normally participate in such enrichment or outreach activity.

11.4 Additionality

All of the activities reported from CFOF are perceived to be **additional** and would not have been funded in the absence of the programme. Further added value comes from such aspects as **specialist equipment**, the teacher fellowships (which appear to cut across and become involved in **a number of the strands**), and the smaller **networks of practitioners** (e.g. in different HEIs) within CFOF who share resources and discuss practice. In relation to school participation, it will be important to build on this additionality by **encouraging a wider range of schools, in partnership with Aimhigher**, to participate further. This should include schools that are harder to engage and those that have not yet participated in CFOF.

11.5 Recommendations

The following areas will be important to consider in the extension phase of CFOF:

- continue to **embed new practices** in schools and HEIs where they have been developed, and **disseminate the resources and approaches** developed through CFOF:
  - **across all CFOF strands**, contributing further to programme integration
  - to the **rest of the chemistry community**, making clear where they can be used ‘off the shelf’ and/or be customised to fit particular student/course needs
- **‘widen the net’** to engage schools who would not normally participate in STEM enrichment or outreach activity
- invest in a **planned series** of activities rather than one-off experiences for young people (and their teachers), given the finding that more positive and long-term outcomes are realised when young people undertake a range of different chemistry activities
- **identify** those young people where CFOF is making a difference to their intentions to take chemistry further and focus attention on **consolidating and deepening** impacts for them (for example, with further targeted information and activity) (this will complement the wide net of broad impacts achieved so far)
- improve the **emphasis on and integration of careers information** in activities involving school pupils, including by developing partnerships with relevant employers and industries.

In addition, the extension phase of CFOF will require collaboration with other STEM organisations. The RSC will need to:

- plan for the **sustainability** of activities, e.g. through links with other regional STEM work
- work closely with the other HEFCE funded SIVS (strategically important and vulnerable subjects) programmes (Stimulating Physics, London Engineering Project, and More Maths Grads) to develop a **coherent STEM-based national programme** for roll out in July 2009.

Beyond the CFOF programme, staff from organisations planning for the national STEM-based programme should also consider the recommendations, and the challenges, highlighted in this report. In particular, adequate **lead-in time** (e.g. for the recruitment of staff, and programme planning) prior to the delivery of the national STEM-based programme will be important. In addition, clear aims and objectives with measurable and realistic outcomes (not just outputs and activities) should be defined during the planning stages. The recent SIVs (Strategically Important and Vulnerable Subjects) programme report stresses the importance of providing 'measures of success at the outset … this would involve the specification of measurable but realistic outcomes, and the demonstration of a relationship between financial investment and identifiable returns' (Adams *et al*., 2008, p.28[7]). However, it is also important to note that openness and flexibility of aims allows participants to experiment, to find out what works and what doesn't work: this was a key strength of the CFOF programme.

[7] Adams, J., Mount, D.R., Smith, D.N. (2008). Strategically Important and Vulnerable Subjects: an interim evaluation of HEFCE's programme of support. Available [online]: http://www.hefce.ac.uk/Pubs/rdreports/2008/rd09_08/ 5th January 2009.

Appendix A: Chemistry for Our Future

This section provides a descriptive overview of aims and objectives of the Chemistry for our Future (CFOF) programme and its four strands.

A1 Programme overview

The CFOF programme is designed to ensure a strong and sustainable chemical science base within higher education and provide a sound base for the continued success of the chemical science industry and 'chemistry-using' companies in the UK.

The key objectives of the programme are to:

- work with schools, colleges, industry and HE around the country promoting chemical sciences as a stimulating and profitable career route
- raise the aspirations of school pupils and widen and significantly increase participation in HE chemical science courses, particularly for under-represented groups[8], thereby sustaining chemistry as a strategic subject
- improve liaison and hence understanding across the key educational interfaces (primary, secondary, tertiary and employment)
- investigate the best use of university chemistry laboratories and staff to deliver effective and efficient use of resources and provide good value for money
- review and develop HE teaching and learning (curriculum development) to ensure fitness for purpose with regard to educational outcomes for student participants and the skills and training needed by employers in both the chemical and non-chemical sectors
- explore opportunities for progression from vocational routes
- provide a cohesive set of opportunities for teachers and students by working with the wide range of organisations and initiatives already involved in STEM promotion activities
- raise awareness of the key role chemists play in the development of sustainable future for all and to demonstrate that chemists provide many of the solutions for the global challenges faced in the C21st.

[8] Under-represented groups include: people whose family have no experience of HE and young people in care; young people from neighbourhoods with lower than average HE participation; people from lower socio-economic groups; minority ethnic groups; people living in deprived geographical areas, including deprived rural and coastal areas; gifted and talented learners who have the potential to benefit from HE but who otherwise might not do so.

The overall intended outcomes of the programme are detailed in the table below.

Quantitative outcomes
An upward trend in applications as shown through UCAS application data
An upward trend in applications to chemistry and chemistry related courses (code F1) as shown in UCAS application data
Increase in A-level grades by participation on events measured through school and college data
Opportunities for vocational progression routes identified and gaps filled especially through work-based learning
Qualitative outcomes
Increased collaboration and communication between HEIs and employers
Increased appreciation of the career opportunities through a chemistry education
Increased awareness of chemistry and its applications to daily life by school and university students and the wider public

The original timetable for the programme is set out below.

Date	Activity
April 2006	Establish robust management systems and recruit staff
September 2006	Establish project teams and initiate individual projects
January 2007	Project delivery underway
April 2008	Preliminary report to HEFCE and request for continuation funding to 2014
June 2008	Formal request to HEFCE for continuation funding
September/October 2008	Programme ends and report submitted to HEFCE on pilot phase

Towards the end of 2007 HEFCE decided that the programme team could tender for a year’s funding to extend the pilot. This application was successfully submitted in March 2008. There is now an extension phase of the CFOF programme, from September 2008 to July 2009.

The CFOF programme consists of four principal strands with two cross-cutting themes. These are described in the sections below.

The programme is managed by the Royal Society of Chemistry (RSC). The programme management team originally consisted of four full-time members of staff. Maternity cover was in place for one member of staff from November 2007 to October 2008. An additional member of staff to work on Strand 3.1 was appointed in 2007 due to the heavy programme workload.

A2 Strand 1: University and Industry Outreach to Schools

Strand 1 is being managed by the RSC and regional co-ordinators have been appointed in each of the six regions involved in this strand. The East Midlands, North West and London regions were already involved in the previous Chemistry: The Next Generation (CTNG) project and through CFOF an additional three regions have become involved in this project. They are: Yorkshire and the Humber, North East and South East. Each region has a part-time co-ordinator.

The aims of Strand 1 are to:

- provide a diverse range of chemistry outreach activities in university laboratories and industry
- provide chemistry outreach activities for students at schools and colleges and/or at regional events
- develop 10-15 outreach materials for national dissemination
- develop regional subsets of the chemistry outreach website
- provide Spectroscopy in a Suitcase in three regions
- develop the e-mentoring infrastructure

The project partners include universities and industry. The industrial partners include: GSK, AstraZeneca and Pfizer. The universities involved in Strand 1 are shown in the table below.

London	East Midlands	North West
Imperial College	Nottingham	Manchester
Greenwich	Nottingham Trent	Manchester Metropolitan
Kingston	Loughborough	Liverpool
University College London	Leicester	Liverpool John Moore's
Yorkshire and Humber	**South East**	**North East**
Huddersfield	Sussex	Newcastle
York	Southampton	Sunderland
Sheffield and Sheffield Hallam	Reading	Teesside
Bradford	Oxford	Durham
	Surrey	Northumbria

The total funding for the strand is £1,317,994 and targets include:

- 7,000 students per year to participate in chemistry outreach activities in university laboratories and industry
- 8,500 students per year to participate in outreach activities and/or regional events
- 10-15 outreach resources
- regional subsets of the chemistry outreach website
- provide Spectroscopy in a Suitcase in three regions.

The scheme was targeted to be fully launched in September 2007.

A3 Strand 2: Supporting Key Educational Interfaces

Strand 2 is managed by the RSC and funds an exchange fellowship scheme for teachers. The main aims and objectives of this strand are to:

- improve academics' knowledge of: the content of A-level chemistry and GCSE science courses; current teaching practices in schools; the types and range of pedagogy used; the practical work undertaken by students and the capabilities of incoming undergraduates
- raise awareness amongst teachers – and students, their parents and guardians – of what it is like to study chemistry at university, the benefits

of higher education and the career options available to chemical science graduates

- develop strategies for bridging the gap between school and university chemistry courses, both in terms of content and practical experience
- develop sustainable links between schools and universities.

Three year-long, full-time teacher fellows and two part-time (one day a week) fellows were in post for the academic year 2007–2008. Two other full-time fellowships started in January 2008 – for one, and two terms. The universities involved in this strand are: Sheffield, Nottingham, Warwick, Birmingham, Bath, Leeds and Reading. The total budget for this strand is £282,000.

A3 Strand 3: HE Chemical Sciences Curriculum Development

This section presents an overview of the progress and outcomes to date of Strand 3, the Higher Education Curriculum Development strand. The strand is broadly focused on developing the HE curriculum to ensure that courses take into account the needs and expectations of students, and provide them with the skills that employers want. It is being overseen by The University of Manchester and includes four separate elements with a total funding of £1,115,000. The funding allocated to each of the four elements is shown in the table below.

Project	Strand	Funding
3.1	School-to-university transition	£415,000
3.2	Chemistry for all – alternative approaches to chemistry curricula	£280,000
3.3	An open learning framework for sustainable part-time provision	£300,000
3.4	Mastering Bologna	£120,000

Strand 3 is being overseen by the University of Manchester. It includes four separate projects with a total funding of £1,115,000. The funding allocated to each of the four projects is shown in the table below.

Project	Strand	Funding
3.1	School-to-university transition	£415,000
3.2	Chemistry for all – alternative approaches to chemistry curricula	£280,000
3.3	An open learning framework for sustainable part-time provision	£300,000
3.4	Mastering Bologna	£120,000

Strand 3.1: School to university transition

Ten projects are to be funded under Strand 3.1 and projects are broadly split into two themes: student support initiatives and improving maths and practical skills. Their aims are to:

- develop first year undergraduate curricula that best support the school-to-university transition
- widen the uptake of chemistry by producing an attractive first year of study
- improve the retention, especially of widening participation students
- inspire new undergraduates.

The universities involved in this strand are: York, Reading, Bath, University of the West of England, Manchester, Southampton, Bristol, Hull, Warwick and Loughborough. Six universities have been awarded £45,000 for two years and four projects have been awarded £45,000 for one year.

Strand 3.2: Chemistry for all – alternative approaches to chemistry curricula

Led by the University of Leicester, this project is focused on providing a data set for evaluating the effectiveness of context based learning (CBL) and problem based learning (PBL) approached in modern university chemistry curricula. The aims and objectives of projects are to:

- implement existing CBL/PBL materials into undergraduate chemistry courses
- measure the effects of these alternative approaches with different student groups (e.g. part-time, distance learners, different stages, Foundation

degrees) in terms of student performance, student satisfaction and engagement, staff perception and resource implications

- investigate the transferability of existing CBL/PBL materials to institutions other than those where they were initially developed
- survey existing and/or related materials that are central to the current project e.g. those being used in other institutions
- share good practice, ideas, materials and innovation and provide rational cross-discipline planning in collaboration with the parallel HEFCE funded Institute of Physics project – 'Stimulating Physics'
- identify areas for future development
- develop some new materials tailored for the delivery of CBL/PBL approaches.

The universities involved in 3.2 are: Leicester, Hull, Nottingham Trent and Plymouth.

Strand 3.3: An open learning framework for sustainable part-time provision

The universities involved in 3.3 are: Manchester Metropolitan, Hull, Greenwich, The Open University, The University of Manchester and an analytical consultant, Brian Woodget. The modules included and the institutions involved are as detailed below. Levels are shown in brackets.

Title	Institution
a) Access to chemistry (0)	Open University
b) Structure and bonding (1)	Hull
c) Organic chemistry (1)	Manchester
d) Physical chemistry (1)	Greenwich
e) Learning through work (1)[a]	MMU
f) Analytical chemistry (1/2)[b]	Consultant

[a] To be prepared in the 1 year extension if funding successful [b] 20 credit module, with material at levels 1 and 2

The original aim of this project was to develop an open and distance learning framework to sustain the future of part-time HE provision in chemical and analytical sciences. There was to be a particular focus on widening participation and sustaining a skilled workforce for the chemical science business sector.

The objectives of this project were to:

- customise and focus the expertise and resources of the consortium of stakeholders to underpin sustainable development of part-time education in chemical science
- develop a national upskilling curriculum resource for distance learning HE provision
- develop new curriculum resources and appropriate pedagogy that will integrate with modern learning technologies and serve sector industries
- enhance the accessibility of part-time study and expand e-learning capacity
- support the integration of under-represented sectors on HE: those without formal qualifications, mature learners, career-break returners, improvers, updaters and specialisers
- underpin and expand existing part-time provision for those in chemical science employment across England
- produce a foundation portfolio of modules in chemical and analytical science of importance to GNP-producing industries such as chemical, pharmaceutical, nuclear, polymer, food, health, materials as well as service-sector businesses such as environmental monitoring, quality control, forensics etc.
- build the foundation of a transferable, industry-standard CPD model for technical and professional career chemists generally.

The proposed outcomes of this project were:

- portable curriculum materials for all HE providers of chemical and analytical science
- curriculum resource packs of underpinning chemistry and competence-based skills specifically part-time, distance learning, blended-learning and e-learning and learning through work (up to 120 credits)
- an ‘Autonomous Learner Toolkit’ for the chemical sciences
- ‘road-tested’ e-learning modules in chemical and analytical science
- enhanced engagement between employers, HEIs and Cogent National Skills Academies (processing and nuclear)
- stakeholder intelligence data (surveys from employers, providers).

However, after an initial meeting of the project partners, it was agreed that the original aims of the project were too ambitious during the short timescale of the project. It was, therefore, agreed that the project would focus on developing six new distance learning materials. Revised plans were submitted to HEFCE in April 2007, these plans were fully approved at the beginning of July for the development of the open learning resources.

Strand 3.4: Mastering Bologna

Led by Imperial College London, the focus of this project is on formulating a strategy to enable UK chemistry departments to meet the requirements of the Bologna process. The aims and objectives are to:

- determine the funding requirements for the additional year of training in the Bologna Masters (notably the second year of Masters training)
- map out key areas of Masters provision that would be best undertaken under the aegis of a chemistry department
- determine the levels and models of Masters course provision required for the industrial and academic base
- determine how the Bologna structure can be integrated with non-Bologna models for the internal UK market and the international market
- develop models of Masters training that enable inclusion of mature students and short-course activities for industry
- develop common entry and exit points under the Bologna model in order to optimise recruitment levels
- monitor developments with the Bologna process throughout Europe.

The universities involved in 3.4 are: Imperial College, Huddersfield, Bath, St Andrew’s, Nottingham, Liverpool John Moore's, Birmingham and Durham. A report has been prepared by Imperial College on the degree of alignment of UK chemistry with the Bologna process, and any changes necessary to achieve alignment.

A4 Strand 4: Widening Schools’ Access to University Laboratories

The focus of Strand 4 is on investigating how HE laboratory facilities can be better utilised by local schools and colleges and for initial teacher training and CPD. This strand involves the universities of Bristol and Sheffield which are investigating two different models of provision. Bristol University is responsible for coordinating this strand.

The University of Bristol ChemLabs are a HEFCE Centre of Excellence in Teaching and Learning. The laboratory facilities are primarily for undergraduate teaching and this project will investigate the potential for their use with schools.

Designated, refurbished university laboratory facilities at the University of Sheffield will be used to support the teaching of practical chemistry to local school and college students, initial teacher training at the university and teacher CPD in conjunction with the local Science Learning Centre.

The specific aims and targets of Strand 4 are detailed below.

The aims of the Sheffield laboratory are to:

- use designated university facilities with up to 1,500 AS and A2 school students
- produce a range of curriculum based pre-packaged experiments.

The aims of the Bristol laboratory are to:

- use university facilities with up to 2,000 school students
- develop two-day taster sessions for year 11 students who have just completed GCSEs
- develop a suite of experiments for key stage 4, AS and A2-level students
- offer revision workshops for GCSE students focusing on structure and bonding, energy and organic chemistry
- offer research opportunities for students performing extended A-level projects.

£78,000 has been allocated to Sheffield University for the refurbishment of the laboratory (£29,000) and the development of practicals, laboratory running costs, staff time and consumables. £100,000 has been allocated to Bristol for the development of practicals, laboratory running costs, staff time and consumables.

A5 Cross-cutting themes

The CFOF programme includes two cross-cutting themes:

- Theme 1: Careers - activities researching and improving the employability of chemical science graduates and increasing interest amongst pupils/students in pursuing a chemical science course of career
- Theme 2: Sharing good practice.

Theme 1: careers

There are four key activities within Theme 1:

- a study exploring what makes chemical science graduates employable
- chemical science careers resources
- work experience opportunities
- careers fairs.

The aims and funding for these four areas are detailed in the table below. The total funding for Theme 1 is £190,000.

Theme	Aim	Funding
What makes chemical science graduates employable?	To undertake a comprehensive survey to investigate the factors affecting the post-university employment of chemical science graduates in the UK	£90,000
Chemical science careers resources	To develop and disseminate a careers DVD in partnership with the Music Factory, featuring footage and interviews with chemical scientists	£45,000
Work experience opportunities	To undertake an analysis to determine the barriers to chemical science companies offering work experience placements for students	£5,000
Careers fairs	To provide three regional events for students and two regional events for careers advisers	£50,000

Theme 2: sharing good practice

The aims of Theme 2 are to:

- disseminate programme outcomes and examples of good practice
- organise two national conferences
- organise 12 regional meetings
- produce four six monthly newsletters
- exploit opportunities to promote the programme in national and regional media

- disseminate information to HEIs, schools and colleges through: project partners, Aimhigher, STEMNET, HE Academy, RDAs, trade associations and other professional bodies; websites; publications/magazines; networks; email contact lists and regular mailings; and through internal services such as the RSC Schools and Colleges Publication Service
- publish and disseminate case studies on the programme via Head of Chemistry UK
- produce new materials for use in schools and colleges

A total of £40,000 is available for Theme 2.

Appendix B: About the research

B1 Aims and objectives of the evaluation

The overall aim of the NFER's evaluation is to evaluate the progress and impacts of the CFOF programme. The evaluation aims to determine the success of the pilot programme as a whole, as well as whether the individual strands have delivered their objectives.

The following research questions are being addressed:

- To what extent does each individual strand meet its aims?
- To what extent is the programme coherent overall? How do the individual strands contribute to the whole? Are there any gaps?
- Do the activities change young people's attitudes towards chemistry for study and careers, including perceptions of transitions from school to university?
- Do the activities change attitudes, cultures and practice amongst teachers and schools, and within higher education institutions (HEI) and industry?
- To what extent does the CFOF targeting strategy support and promote chemistry for study and careers? Who is targeted? How?

And, at this pilot stage, what can be said about the following:

- Do the activities raise young people's attainment in science at GCSE and chemistry at A-level?
- Is there cumulative impact from one activity on another? What do the learners experience and gain over time? What do the teachers and HEI staff experience and gain over time?
- Does the evidence provide early indicators of increased participation in chemistry in HE?

The evaluation will also inform the future development of the programme through:

- exploring how each strand might be evaluated so as to provide comparable data across the programme
- drawing out common learning across the strands, and feeding into the sharing of practice.

B2 Methodology

The evaluation methodology recognises that this is a pilot programme, spanning two years, and that any change programme takes time. The evaluation has a mixed-methods design, in which core sets of questions/data collections have been devised around the following key areas:

- programme and strand aims and processes (research questions 1 and 2)
- attitudinal change (research question 3)
- cultural and practice change (research question 4)
- targeting (research question 5)
- attainment (research question 6)
- participation (research question 8).

By tracking the progress and outcomes of the strands over the course of a year, the evaluation also addresses research question 7. In addition, the pupil survey administered at two time points, and written up in section 10 of this report, provides findings on the nature of impact from one-off versus multiple experiences.

The following evaluation methods have been used to explore the CFOF programme overall:

- meetings and interviews with programme and strand managers
- desk research on existing evaluation data for the programme and strands
- development of standard evaluation tools (for example, standard pupil and teacher evaluation sheets have been devised by NFER for aspects of the CFOF programme)
- development of a longitudinal questionnaire to explore changes in young people's attitudes and possible destinations over time (baseline questionnaires have been administered in the case study schools for Strands 1 and 4).

Over the course of the year, we have conducted the following:

- Strand 1: case studies with five schools (including interviews with 20 pupils and five teachers); survey administration to 110 school pupils, and follow-up 'tracking' surveys with 46 of these pupils some six to nine months later; follow-up telephone interviews with four teachers in the five case study schools; a focus group and questionnaire proformas with the six regional coordinators; telephone interviews with the CTNG national manager; and consultations with the coordinators of Future Blogs and Spectroscopy in a Suitcase. In addition, we have explored 'standard pro-forma' data and findings from the CTNG database (data provided by the RSC).

- Strand 2: interviews with seven teacher fellows early on in their fellowships; follow up with the teacher fellows in July 2008 either by phone or e-mail; questionnaire proformas with six of the seven HEIs, and four of the fellows' schools; and telephone interviews with the RSC coordinator for Strand 2.
- Strand 3.1: case studies with four projects (including interviews with academics and undergraduates); pro-formas and e-mails from six projects detailing impacts; exploration of monitoring reports sent by all projects to the RSC in January 2008; exploration of monitoring report sent by RSC to HEFCE in September 2008; interviews with Strand 3.1 project officer at RSC and university coordinator.
- Strand 3.2: data collected by the NFER at a meeting of Strand 3 deliverers held on 29th November 2007; a meeting of project partners held on 18th December 2007; telephone interviews with project partners and the project coordinator conducted in November 2007 and June/July 2008; attendance at the CFOF 2nd National Conference held in July 2008; and exploration of reports and evaluation data provided by projects. This includes an initial evaluation report written by the external evaluator working on the project and a paper written by the project partner at the University of Plymouth.
- Strand 3.3: interviews with all five project partners.
- Strand 3.4: exploration of monitoring report sent by RSC to HEFCE in September 2008.
- Strand 4: case studies with five schools (including interviews with 23 pupils and five teachers); survey administration to 95 pupils; follow-up telephone interviews with three teachers; initial and follow-up interviews with the laboratory managers from each site (Bristol and Sheffield); and consultation with the overall strand manager.
- Programme overview: meetings and interviews with the national CFOF programme manager; attendance at RSC events such as the National Conference in July 2008; telephone interviews with four members of CFOF national committees (e.g. Project Advisory Group, Steering Committee); and ongoing contact and conversations with relevant staff at the RSC.

Appendix C: Progress of Strand 3.2: Chemistry for All project partners

C1 University of Leicester

Introduction

The focus of Strand 3.2 work at the University of Leicester is on developing new context- and problem-based materials and delivering them within what has been, up until now, a traditionally taught chemistry degree curriculum. CBL/PBL has been introduced into the core physical and inorganic module in the first year chemistry degree. 84 students started this degree in the 2007/8 academic year. CBL/PBL has also been introduced into a chemistry foundation year (19 students started in 2007/8) from which students continue onto the three year chemistry degree course.

Evaluation of CBL/PBL in the chemistry degree

The CBL/PBL sessions for the chemistry degree that have been developed have drawn on the expertise of the project coordinator in using CBL/PBL approaches within physics and on the CBL/PBL approaches developed by the project lead for Leicester's i–science degree. Materials, methods and approaches to implementation were developed between April and September 2007, with half of the sessions being written from scratch and the others being developed from existing sessions.

As mentioned above, CBL/PBL has been introduced into the core physical and inorganic module (CH1000) in the first year chemistry degree. Two CBL/PBL sessions a week were delivered from October 2007 and the work that students completed contributed 15 per cent to the 20 credit module. Two multiple choice questionnaire (MCQ) tests (total 15 per cent), tutorials (10 per cent) and an exam (60 per cent) also contributed to the assessment of the module. The structure of the module in 2007/8 is shown below and a comparison is made to the way that it was delivered in the previous academic year. All sessions were one hour long. The number of maths sessions (10 lectures and 10 workshops) and MCQ tests (2) remained the same over the two academic years.

Table C1: Module structure comparison: physical and inorganic chemistry module (CH1000), year one chemistry, 2006/7 to 2007/8

Delivery method	2006/07	2007/08
Lectures	28	20
Workshops	4	3
Underlying Workshops	6	0
PBL Contact Sessions	0	18
Total	38	41

Also new to Leicester has been the delivery of sessions using a wiki (an editable web page). A problem wiki includes all of the information about the module including the staff running it, a guide to CBL/PBL, the problem statements and links to resources. The 84 students on the CH1000 course were divided into 17 groups each of 5/6 students. Student groups were given a group folder on the module's Blackboard site (the virtual learning environment (VLE) employed at the University of Leicester) and all of their work was delivered through a group wiki within this folder. As they learned and acquired new knowledge, students could return to previous assignments and make alterations even after the deadline. Staff monitored the progress of each group on a weekly basis by looking at their page on Blackboard. In addition, facilitators provided feedback by leaving comments on the group's wiki and by discussing work with students in contact sessions. Students also left comments on the performance of their group members on Blackboard. Marks were given for each group assignment and students also completed an individual assignment as part of the CBL/PBL component of the module with the CBL/PBL component making up 15 per cent of the module's marks, as noted above. Students

The two MCQ tests which students in the 2007/8 academic year completed were also taken by three previous student cohorts. The average mark for these two tests has stayed virtually the same for all four years (65 per cent) despite the fact that student numbers have grown from 57 to 84. The marks achieved by students over the past four years are shown in the table below.

Table C2: CH1000 multiple choice question (MCQ) test results

Test 1	Number of students	Lowest mark	Highest mark	Average/20
Oct 2007	84	7.83	20	14.7
Oct 2006	60	6.33	20	14.85
Nov 2005	57	5.6	19	14.3
Nov 2004	57	5	20	14.1
Test 2	**Number of students**	**Lowest mark**	**Highest mark**	**Average/20**
Dec 2007	83	5	20	11.77
Dec 2006	59	6	17	11.24
Dec 2005	52	6.5	20	11.48
Dec 2004	53	3	19	11.54

In relation to exam results, a comparison is also possible over the last four years. Looking at the results shows that this year's mark (49 per cent) lies within the range for this period of time although it shows a decrease from the previous two years' marks (54 per cent in 2006/7 and 58 per cent in 2005/6). However, the increase in this year's cohort size may have impacted on the average exam mark. In addition, the exam format was changed this year (three questions in two hours, instead of four questions in three hours) to compensate for the extra work/assessment of the CBL/PBL element. Given the relatively small changes (compared to year on year variation) it is not possible to read too much into the results from one year.

Table C3: CH1000 exam results

	Exam Average %	Module Average %
Jan 2008	49	54
Jan 2007	54	58
Jan 2006	58	62
Jan 2005	45	50

The overall average mark for the module in 2007/8 was 54 per cent which was better than the exam mark, which has also been the case in previous years. However, the overall average of 54 per cent was a decrease on the previous two years. Some small teething problems (see below) have been identified which will be resolved for next year which should lead to increased marks.

Overall, the CBL/PBL approach has neither had a positive or negative impact on the attainment of first year chemistry degree students. It is, therefore, considered as a success. Exam based assessment can often lead to higher marks with students trained to pass the exam but it does not necessarily produce students who are able to think for themselves, and who can use materials from other modules, and who will have the skills required to succeed in employment. The advice is to not expect too great an increase in students' understanding, particularly in the early stages of introducing CBL/PBL. However, feedback from students suggests that there are some key benefits in other areas as a result of the involvement in CBL/PBL.

Much of the feedback received from students at Leicester focuses on two main themes: increased student motivation (which has directly affected the learning process) and the social aspects of group work. In terms of motivation, students report that the problems have given them a chance to apply concepts learned in lectures to realistic scenarios which has increased their motivation for their studies: *'The idea is really good where the problems are related to real life, applying scientific knowledge to real-world situations'* and '*It mimics industry'*. However, some students report that the script used as one of the staging items actually obscured the problem rather than making it more accessible. As a consequence of this, the script has been completely rewritten for the 2008/09 academic year with the focus now being more on the science rather than the storyline. Feedback gathered in relation to the group work aspects of CBL/PBL seems to show that students appreciate the benefits of working within a group with those they do not know or would not otherwise choose to work with. Student comments on the social aspect of CBL/PBL include: '*Teaches you to work in a group with different group members'*. This has led to students developing new friendships which staff feel will have a beneficial impact on retention.

Some students have commented that it is frustrating when groups do not *'gel'*. However, only a minority of students highlight negative aspects of group work and it seems likely that some students will always be more comfortable working alone than in a group. It is, however, advisable for staff delivering CBL/PBL sessions to change groups from time to time so that students work with other students and so that all experience working in an effective group. Feedback from staff on the practicalities of delivering via CBL/PBL suggests that it is time intensive, particularly in terms of its use of postgraduate demonstrators/facilitators. Additionally, there have been some issues in terms of accessing suitable accommodation for CBL/PBL sessions. In some cases, due to pressure on space, lecture theatres and staff offices have been used for sessions which are not conducive to group work activities and can reduce the impact of the approach.

Looking at the retention rate of the 84 students who started the first year of their degree in October 2007, 74 (89 per cent) progressed into year two. This compares to 53 students progressing from an intake of 64 (83 per cent) in 2006/07 which suggests that using CBL/PBL in the first semester could have positively impacted on student retention.

Evaluation of CBL/PBL in chemistry foundation year

CBL/PBL has also been introduced into the second semester of the foundation year of a four year BSc in chemistry (19 students). This foundation year has now been integrated into the degree course, forming the first year after which students then progress onto the three year degree. The foundation year is for students who do not meet Leicester's entry requirements for the chemistry degree. In previous years, the foundation year was taught at other institutions after which students progressed onto a chemistry degree at Leicester. The CBL/PBL approach is primarily being used in teaching physical and inorganic chemistry topics such as thermodynamics, energy, stoichiometry and kinetics. Students have received a one hour introduction to the topic to be studied and have then worked in groups with support from a staff member facilitator for two additional one hour sessions. In total, students have been involved in 20 hours of CBL/PBL sessions supported by nine lectures. Some ideas and approaches have been taken from the University of Delaware, which has an on-line CBL/PBL database of materials, and other problems and materials have been developed entirely in-house. Feedback suggests that staff at Leicester have found it relatively easy to trial the introduction of modules from other universities, including from the Delaware PBL website, into their courses. However, it is worth noting that, in many cases, staff need to put in significant time to adapt CBL/PBL materials from different institutions to their own context and to adjust to this new approach to teaching and learning

During the foundation year, the CBL/PBL approach has been useful in teaching topics whilst also improving students' study skills. The perception from staff is that many students would have achieved better grades at A-level if they had good study skills.

The feedback from foundation year students regarding the CBL/PBL approach is generally good and only a small minority of students are less favourable about the approach. This small number of students tend to feel that they are out of their ‘comfort zone’ since they are involved in an approach to learning which they are unfamiliar with. However, the majority of students recognise the benefits of the CBL/PBL approach, which makes them think in a different way to what they are used to and involves applying material they have covered in previous modules. Students can initially find drawing on and applying learning from other modules difficult but they recognise that they benefit from this approach. The group work element is also useful in that it helps students to bond and make friends with others through working closely with them in a group. Since there were only 19 students on the foundation course at Leicester, group dynamics have been good with students being very supportive of each other. As a member of staff reports: ‘*PBL creates a community of students and strong links between students and staff. It really helps; students feel part of the department and are more likely to want to stay*’. The development of transferable skills, such as communication and planning has, in addition, been a major advantage of running CBL/PBL to this group of students.

The average mark for the module was 51.2 per cent, one student failed the module (this student failed to turn up for the vast majority of sessions both on this module and all others). As the foundation year module was a new module, there are no marks to compare it with.

In relation to retention, out of an initial group of 20, two students failed to progress from the foundation year. This retention rate of 90 per cent is high which suggests that students are happy with the content and delivery of the course, including the CBL/PBL aspect.

Involvement of staff within CBL/PBL

In terms of staff commitment to CBL/PBL, this has grown over the course of the project and, now, rather than it being taken forward by individuals in departments, it is being taken forward by teams. There has been a significant change in attitude amongst staff and introducing CBL/PBL is seen to be an important element in the chemistry department’s strategy. Staff who have not been involved in delivering CBL/PBL have benefited from students being more confident in working together and being more interactive with staff generally. Seeing the impact on students has led to staff seeing the benefits of the approach.

Other activities undertaken

In conjunction with representatives from the Universities of Hull and Plymouth, a representative from Leicester presented at a Science teaching and learning event in Leicester. This staff member also ran workshops at the HEA Subject Centre for Physical Sciences Special Interest Group. In addition, Leicester representatives have also presented at the sixth annual summer PBL workshop held at Leicester and at the Variety in Chemistry meeting this year in Dublin.

In relation to working with the other three project partners, Leicester staff feel that they have benefited from their partnership working with other universities involved in Strand 3.2 of the CFOF programme, particularly from those universities which are further ahead in their development of CBL/PBL within modules.

Future plans

Leicester intend to introduce CBL/PBL into other modules, thereby increasing the emphasis on this approach in the first year of the degree and introducing it into years two and three so that students build up their experience over time and continue to be set problem solving exercises. The first step will be to introduce CBL/PBL into the second year of the degree course which is planned for the 2008/9 academic year. Introducing CBL/PBL into the third year will then happen in 2009/10. As CBL/PBL becomes more embedded throughout the degree, there will be a need to persuade new members of staff to incorporate it into modules.

Close links are also being retained with the i-science degree in physics and resources are being exchanged on an on-going basis.

C2 Nottingham Trent University

Introduction

Similar to the situation of Leicester, the use of the CBL/PBL approach is relatively new to Nottingham Trent University and only a small amount of

CBL/PBL was delivered prior to the university's involvement in CFOF. The focus of Nottingham Trent's activity is on exploring the issues faced in using CBL/PBL materials developed elsewhere and encouraging staff to use them. CBL/PBL materials have been used within the chemistry cluster of subjects, of which some materials have been laboratory based.

Using CBL/PBL within laboratory work

Two types of laboratory developments have been undertaken. Firstly, a set of existing practicals have been contextualised by modifying existing physical chemistry laboratory classes into CBL/PBL scripts. In this work, Nottingham Trent have drawn on CBL/PBL practicals devised elsewhere. These CBL/PBL scripts have been used with one group of first year forensic science students (15 students). Laboratories have been run on a three week rotation basis and students have carried out three out of four possible experiments (one of which was an 'old' script for comparative purposes). Student questionnaires have been used to evaluate the effectiveness of the CBL/PBL materials and findings from ten students suggested that they feel strongly that:

- physical chemistry is an important aspect of forensic science, and they were not always sure that the existing physical chemistry module tied in with forensic science
- the 'new' contextualised physical chemistry laboratory scripts were more interesting/engaging
- the physical chemistry experiments would be better if they had a more forensic context
- the CBL/PBL supervisor/technician helped students with difficulties and recognised that students differ in their needs, concerns and interests.

A detailed evaluation of staff perceptions has not been carried out due to the loss of the staff member. However, informal staff comments have suggested mixed reactions, with room for further fine tuning of CBL/PBL materials.

Secondly, laboratory scripts for year two inorganic laboratory classes have been developed and delivered in term two of the chemistry degree (two groups of students, a total of 45). A suite of four inorganic experiments have been created as part of the second year 'circus' of experiments. These are CBL/PBL modifications of typical inorganic practicals. These practicals have run alongside procedures with a more traditional approach, which has allowed comparisons to be made. The scripts have not been evaluated formally.

However, informal comments have revealed resource issues with one practical and work is being undertaken to develop an improved version tackling different areas for the 2008/9 academic year.

Tutorial support

A tutorial pack for organic chemistry has been developed using newly created CBL/PBL resources, that link in with difficult concepts from lectures, with the aim of increasing students' understanding. These packs were distributed to all year one students on the chemistry programme (55 students) throughout term one as tutor groups rotated between physical, inorganic and organic chemistry. CBL/PBL sessions have been delivered within tutorials and how they worked is currently being evaluated with the intention to refine and improve sessions in the 2008/9 academic year.

CBL/PBL resources have also been incorporated into chemistry tutorials for year one forensic science students (12 students). Standard paper-based materials have also been used for comparative purposes.

Using CBL/PBL within case study investigation

As part of Nottingham Trent's work in evaluating the issues raised by introducing CBL/PBL materials developed elsewhere, 'On the River Bank', developed by the Universities of Plymouth and Hull, has been delivered to year three students on the environmental science degree (there are 10-15 students per year on this course). Qualitative feedback has been gathered from students and anecdotal evidence from staff. Students had not been exposed to this type of work/assessment before and were, as a result, a little unsure initially as to how to apply themselves to the task required which resulted in staff spending more time with students in the introductory sessions providing them with information and guidance. However, data from the module feedback forms suggests that students really enjoy and engage with this aspect of the course and would welcome more sessions delivered using the CBL/PBL approach. Feedback from staff suggests that introducing CBL/PBL sessions developed elsewhere works well when they are well constructed and provide enough detail for both the student and teacher, as was the case with this particular case study.

Evaluation

It was intended that all of the materials described previously would be evaluated using a mixture of attitudinal surveys, interviews and questionnaires but, due to the loss of the staff member responsible, it was not possible to carry out evaluation in the way it was originally intended. General feedback from staff did show that, prior to CFOF funding, they were convinced of the need to renew the chemistry curriculum but lacked the time to develop their ideas. The additional funding has allowed areas of experimentation that were not previously possible and staff have been able to put ideas into practice. Difficulties have been experienced in implementing new laboratory-based CBL/PBL materials as technicians are very familiar with older experiments and the availability of instrumentation and chemicals has been an issue in some cases. In relation to students, staff report that the first laboratory group found new CBL/PBL scripts more interesting than traditional versions and liked the use of context based examples.

In general, the learning from the range of activities delivered at Nottingham Trent has been around change management and how to ensure that staff have the necessary confidence, in addition to time, resources and support, to develop and deliver CBL/PBL sessions.

Curriculum survey – *The Shape of Chemistry in 2008*

A major ambition of the work at Nottingham Trent was to carry out a full survey of the content of undergraduate chemistry degrees across England. The intention was that the information obtained from this survey would inform the extension phase of Strand 3.2, and other future curriculum development projects, by identifying those areas of the chemistry syllabus which are widely taught. It would also highlight topics within the curriculum where new CBL/PBL materials could be credibly transferred across institutions. All chemistry programmes at BSc and MChem level which are recognised/accredited by the RSC were included in the survey. This full census has been contrasted with a smaller survey in 1998 of *first year* chemistry allowing an analysis of both the shape of modern undergraduate chemistry as well as illustrating how chemistry has changed since 1998. Ten years ago, first year undergraduate chemistry courses were dominated by spectroscopy, chemical bonding, analytical chemistry and thermodynamics. Subject balance has shifted since 1998 and it is interesting to note which topics have been added, in addition to which topics are disappearing from the first year syllabus and which are being delivered in later years. Important new topics which have been introduced to chemistry syllabi include those in the typical ‘buzz areas’ such as nanotechnology, modelling & simulation.

The survey has not only considered ‘pure’ chemistry courses, but has also examined the vast and varied array of undergraduate chemistry courses known variously as ‘Chemistry and X’, ‘Chemistry with X’ and ‘Chemistry for X’ (where X is ‘another subject’). This raises the questions as to whether many students and employers understand the differences between these types of courses. Similarities and differences in chemistry content have been examined in relation to mathematical content and how content relates to the ‘other subject’ option and the other subsidiary option choices involved. There is a drive for variety with the emergence of diverse courses, with departmental strengths or specialism introduced early, and with a substantially more varied student experience from year one through changes to the syllabus and increased option choices.

The findings of this survey were presented at the Variety in Chemistry Education (ViCE) 2008 conference which was attended by approximately 200 delegates. A paper – *The Shape of Chemistry in 2008* – was presented at ViCE and current collaboration with *Education in Chemistry* Journal will mean that the full survey is to be published. An *opinion* piece is also being prepared for the journal *Chemistry World*.

Review of CBL/PBL materials in chemistry

Nottingham Trent have also been involved in reviewing what CBL/PBL materials exist in chemistry. Additional questions on this have been included in the national surveys of the *Student Learning Experience* for chemistry and physics, which have been undertaken by the HEA Physical Sciences Subject Centre during 2007/8. In collaboration with the HEA Physical Sciences Subject Centre, Nottingham Trent have collected the data. This is being followed up by a more detailed study which is currently underway.

Future plans

Staff at Nottingham Trent have been developing new CBL/PBL activities and resources for use in the new 2008/9 academic year. These will be introduced across all levels of the chemistry degree including ‘M’ level modules for the MChem programmes.

Newly constructed CBL/PBL activities and resources are to be used with first year chemistry students. They will be introduced within a biological chemistry module by providing a forensic context for learning about drug action and efficacy.

A practical activity and resource, which is near completion, will introduce second year chemistry students to how an organometallic chemist goes about designing new phosphorous ligands for use in homogeneous catalysis. Trialling of practical activities is to be completed by the middle of October 2008 and the work is to be introduced soon thereafter. This work is being developed in collaboration with a lecturer in inorganic chemistry at Nottingham Trent.

CBL/PBL activities in the area of environmental chemistry that form an important part of the assessment for the module 'Pollution, Assessment and Control' (PAC) are being further developed. This is a development that is building on the successes of the imported 'On the River Bank' assignment work. An exciting new resource pack that has been constructed from information supplied by a recent collaboration with Astra Zeneca's Brixham Environmental Laboratory is being implemented in this first term. It is to be implemented into the PAC module and environmental chemistry modules so that subsequent findings, experiences and feedback can be compared.

In addition, new CBL/PBL activities and resources will be introduced to chemistry students in their final year. Within the MChem Advanced Techniques module, students will undertake an exercise titled 'Unlocking the Oxygen Storage Capacity of Ceria'. Students will be introduced both to advanced research of ceria surfaces and to the use of chemo-informatics together with both modern experimental and theoretical (modelling and simulation) techniques and investigation.

Finally, in the new academic year, the scope for the construction of CBL/PBL laboratory activities/resources that will exercise and develop first year physical chemistry students' mathematical and IT skills will be investigated.

C3 University of Plymouth

Introduction

Similar to the position of the University of Hull, staff at the University of Plymouth have been using CBL/PBL, primarily within the third year of degree courses, over the past six years. CBL/PBL case studies have been used in areas such as environmental, industrial and pharmaceutical chemistry and each case study has included the development of key skills. The focus of Plymouth's work for Strand 3.2 is, therefore, on compiling the evidence in relation to the impacts of this approach and the challenges that arise in delivery.

Evaluation of CBL/PBL through case study investigation: student attainment and feedback

Plymouth have been using the case study approach in the teaching of analytical chemistry since 2001/2 across all chemistry degree year groups. This has included the following case studies delivered to year two students:

- 'The Titan Project', which is a case study that requires students to research two different manufacturing processes for the industrial scale production of Ti02
- 'New Drugs for Old', which involves devising short- and long-term investigations of a potentially new analgesic drug isolated from a natural source
- 'Tales of the Riverbank', which requires students to consider some basic principles of analytical measurements within the applied context of pollutant species within a river system.

For each of these three case studies, student groups are assessed using a combination of oral presentations and reports. The assessment criteria focus on the accuracy of solutions to the various problems given the data that is available, together with clarity of presentation. The type of information that students work with ranges from datasets that they are familiar with to cases where they have to make estimates where correct values are unknown.

In addition, over the past seven years, 'The Pale Horse' case study has been used as part of an approach to the teaching of analytical chemistry to year three students and this ‘forensic’ case study forms a component of the coursework element of a module entitled ‘Forensic Analysis’. The case study sets analytical chemistry within the context of a forensic investigation of a fictitious death. Students request physical, chemical and toxicological evidence from a variety of sources and are able to build up an understanding of the cause of death (poisoning), what the poison was, its effects on the individual and his/her family, how it was administered and the motivation of the suspects. The case study is carried out in small groups of 4/5 students over four sessions and groups are assessed via oral presentations and a group report, though the assessment criteria for these are the same. The remainder of the module is assessed through traditional laboratory reports (coursework) and an exam. The assessment criteria require students to present their results and their interpretations and to give an account of their strategy to approaching the problem and the role that analytical chemistry has played in providing a solution. Students, therefore, have to work towards a ‘best-fit’ answer to the problem whilst also thinking about the wider implications of their problem solving. On an on-going basis, students need to evidence planning and changes of direction and need to provide a detailed rationale for specific requests for information as the case study progresses.

Evidence from the delivery of case studies within modules has been systematically collected by the University of Plymouth since the delivery of chemistry courses via CBL/PBL approaches was initiated but, prior to CFOF funding, time and resources were not available to undertake a thorough analysis of the data. CFOF funding has enabled the compilation and analysis of student assessment and performance data to be completed and this has resulted in the production of a paper which is currently out for review entitled *Impacts of assessment in problem-based learning: A case study from chemistry*[9] and which is being submitted to the RSC journal *Chemistry Education Research and Practice*.

The key finding from Plymouth’s analysis of student assessment and performance data for case study activities over the past seven years is that, if you assess CBL/PBL using assessment procedures and criteria which are familiar to students (as is the case for year two CBL/PBL case studies), then they do as well as in other more traditional methods of teaching and learning

[9] *Impact of assessment in problem-based learning: A case study from chemistry*, Simon T Belt, University of Plymouth, August 2008

within the same module. Although they may be unfamiliar with the contextual and, in some cases, open-ended nature of the problems within the case studies, they still do well if they are familiar with the assessment methods i.e. if a high proportion of marks are allocated to students achieving the required solution. The performance data for year two students over the past seven years is shown in Table 6.4 below. It shows that students perform consistently well in case study work with the combined mean being 66.0 ± 7.9 with the annual and combined mean marks for the case study assessments being similar to the parallel marks for the laboratory reports which form the second element of the coursework within the module. The marks for the end of year exams are only available for the last two years, with the combined mean being slightly lower than those for the two coursework components, although the spread of marks is higher.

Table C4: Summary of year two student performance data in case studies, laboratory reports and exams, 2001-2007

Year	Case Study (%)		Laboratory reports (%)		Exam (%)	
2001-2002	73.3 ± 6.9	(n=31)	66.2 ± 10.5	(n=44)	X	
2002-2003	67.2 ± 9.6	(n=23)	65.3 ± 9.4	(n=23)	X	
2003-2004	62.5 ± 3.5	(n=17)	56.3 ± 11.4	(n=17)	X	
2004-2005	69.8 ± 7.9	(n=42)	68.3 ± 14.7	(n=60)	X	
2005-2006	56.0 ± 12.1	(n=22)	57.8 ± 10.4	(n=22)	61.6 ± 12.3	(n=22)
2006-2007	57.3 ± 6.6	(n=15)	64.7 ± 10.5	(n=15)	60.6 ± 15.2	(n=15)
2001-2007	**66.0 ± 7.9**	**(n=150)**	**64.7± 11.8**	**(n=181)**	**61.2 ± 13.5**	**(n=37)**

Source*: Impact of assessment in problem-based learning: A case study from chemistry*[4]

Comparisons between the CBL/PBL marks and other modes of assessment in the ‘Forensic Analysis’ year three module are shown in Table 5 below. As can be seen, the uniformity across different forms of assessment, observed in year two assessments, is not apparent in year three. And, the results show that performance in case study work, though higher than that in exams, is lower than that in laboratory reports. It is felt that, where assessment criteria is more open ended and, for example, includes students discussing reasons for decisions and actions, having a sensible rationale for the methodology and evaluating how the group worked – which has been the case within year three assessments – performance tends to be lower than in other types of assessment, such as laboratory reports, even if the subject matter is similar.

Students' difficulties with this type of assessment are not usually linked to a lack of clarity in the lecturers' description of the assessment process - as half a session is dedicated to this – but more to students finding it difficult to adjust to a new approach to assessment.

Table C5: Summary of year 3 student performance data in case studies, laboratory reports and exams, 2001-2007

Year	Case Study (%)		Laboratory reports (%)		Exam (%)	
2001-2002	56.6 ± 15.2	(n=22)	70.8 ± 8.5	(n=22)	62.4 ± 11.1	(n=21)
2002-2003	56.7 ± 1.3	(n=15)	69.9 ± 9.8	(n=13)	50.5 ± 11.4	(n=15)
2003-2004	57.0 ± 8.9	(n=29)	77.0 ± 11.2	(n=28)	52.0 ± 9.8	(n=29)
2004-2005	57.5 ± 8.5	(n=13)	79.0 ± 6.1	(n=14)	46.2 ± 6.7	(n=14)
2005-2006	60.3 ± 8.9	(n=22)	76.5 ± 11.4	(n=22)	53.2 ± 14.8	(n=22)
2006-2007	57.0 ± 5.6	(n=19)	73.0 ± 10.8	(n=19)	52.3 ± 12.9	(n=19)
2001-2007	**57.5 ± 9.6**	**(n=120)**	**74.6 ± 11.0**	**(n=118)**	**53.2 ± 13.3**	**(n=120)**

Source: *Impact of assessment in problem-based learning: A case study from chemistry* [4]

Additional feedback from students in relation to CBL/PBL suggests that they find sessions motivating and enjoyable, yet frustrating and demanding initially. Over time, they appreciate the fact that they are learning chemistry in context and are developing a range of key skills, including group work, time management and presentation skills, in particular. Quotations gathered from students at the University of Plymouth suggest that students appreciate: '*the real world aspect*', '*the opportunity to put theory into practice*', '*working with others*' and '*getting my opinion across*' as key features of the case study approach and they welcome the opportunity to develop professional skills alongside subject-specific skills[4]. Some findings from the additional feedback gathered from year three students are shown in the table below.

Qualitative feedback from year three students on the case study approach

- 95% of students enjoyed the case study and agreed that it enabled them to make more sense of theory
- 80% of students recognised the value of different assessment styles
- 85% of students disagreed that the case study hadn't taught them anything new
- 80% of students said that their approach at the end was clearly different to that at the beginning
- 60% of students thought that they would have achieved more given more time although 90% claimed to have finished the work on time
- 50% of students would have preferred to have gathered their own data via laboratory work
- No students claimed to not understand the aims and objectives of the case study
- 80% of students recognised the value of both the oral presentation and the report, despite the assessment criteria being the same for both.

Evaluation of CBL/PBL within laboratory work: student attainment and feedback

Plymouth have also used CFOF funding to further develop the usage of CBL/PBL in laboratory work. This includes the development and piloting of new organic chemistry laboratory materials for year one students. An extended laboratory investigation (four sessions) which aims to determine the composition of a common pharmaceutical, Aspirin, and to explore the differences between suppliers was delivered to year one term two chemistry students in 2005/6 and was then further developed and delivered in 2006/7. Students also carried out more traditional, prescriptive style laboratory investigations in term one which enabled the two approaches to be compared.

Plymouth have also piloted materials for an additional case study for use with first year students in the second term. This case study, which was delivered in 2007/8, is a four week investigation into the possible contamination of chewing gum and includes an introduction to flavours and fragrances. The assignment involves students responding to a customer complaint by designing experiments to test hypotheses and working towards an understanding as to how the contamination has occurred. Students need to design and conduct experiments, reflect on their outcomes and, from these, design other experiments. They complete this cycle until they have found a solution and can present their conclusions. When students were asked what the best aspects of the chewing gum module were, their responses included:

- the chewing gum experiment was very interesting, including doing your own work and finding a solution to a problem
- the way in which that laboratories were carried out – the continuation of the laboratory sessions which aided understanding
- working on an interesting problem-based practical that allowed you to try and think about how to go about solving it
- the thought provoking laboratory and tutorial sessions.

An analysis of student marks, comparing marks for traditional/prescriptive laboratories with CBL/PBL laboratories, shows that marks tend to be slightly lower for CBL/PBL laboratories. Between 2005-8, the mean for traditional/prescriptive laboratories was 65 per cent and for CBL/PBL laboratories the marks were 63 per cent (2005/6), 63 per cent (2006/7) and 73 per cent (2007/8).

As well as looking at assessment, Plymouth have gathered feedback from students on laboratory work which has explored views on the importance of pre-laboratory exercises for CBL/PBL laboratories and the delivery of CBL/PBL laboratories themselves. Pre-laboratory exercises have been shown to be particularly important and effective for CBL/PBL laboratories since they are key to preparing students for the CBL/PBL approach to the subject. In addition, students appear positive about CBL/PBL laboratories and appreciate what they learn from them. However, the findings also show that students like the security of working to an agreed procedure. More detail is provided in the box below.

CBL/PBL within laboratory work

Student feedback on the importance of pre-laboratory exercises for CBL/PBL laboratories:

- 88% of students agreed that carrying out pre-laboratory exercises made them better prepared for laboratory sessions
- 82% of students agreed that pre-laboratory exercises created a more dynamic laboratory session
- 86% of students agreed that pre-laboratory exercises prepared them better (than pre-laboratory exercises for prescriptive/traditional laboratories) for the actual experimental work
- Students were asked to rate on a scale of 1-10 to what extent they agreed with the following statement:
- With the structured approach, it is thought that the majority of your thinking is carried out AFTER the laboratory session, whereas with the problem based approach, the majority of your thinking is performed DURING the laboratory session.
- The mean response was 8.4
- When asked what should be the relative contributions from CBL/PBL and structured type laboratory sessions, 86% of students felt that the balance should be 50:50.

Student feedback on CBL/PBL laboratory sessions:

- 94% of students felt that group discussions were an effective way of enhancing their knowledge
- 84% of students felt that contributing to the experimental design improved their understanding of the theory
- 82% of students disagreed with the statement that they would have preferred to have designed their own experimental procedure from scratch and carried out the work, even if no results were obtained
- 78% of students agreed that contributing to the experimental design improved their understanding of practical work
- 96% of students agreed that they liked discussing the experimental design, but then working to an agreed procedure.

Another aspect of Plymouth's work has been exploring the impacts of CBL/PBL material funded through other sources and delivered at other stages in the undergraduate programme, for example physical chemistry year one. However, the evaluation data that has been collected by Plymouth to date is less comprehensive.

Plymouth have also sought feedback from other UK universities who have used CBL/PBL case study materials developed by Plymouth. Copies of a suite of CBL/PBL case study materials, which included suggestions for assessment methods, were sent out to all UK chemistry departments via a previous RSC funded project. Workshops have also been run at which the materials have been described. However, this aspect of the work is proving difficult since evaluation of the material has generally been undertaken on an ad-hoc basis and most of the evaluation data collected by institutions has been anecdotal information.

Dissemination activities

With other project partners, Plymouth staff have been involved in two workshops which have been delivered to academic staff in 2008 on the use of CBL/PBL in laboratories. These have been held at the University of Birmingham to a special interest group in CBL/PBL and at the University of Leicester which focused on teaching and learning in the sciences. A total of 100 delegates attended these workshops and the second workshop was attended by academics from around the country. A third workshop has been run with local school teachers which focused on laboratory work and a fourth workshop was run at the Variety in Chemistry meeting at the end of August 2008.

Future plans

The next stage of development for Plymouth is to design some more first year CBL/PBL laboratory sessions so that they have a suite of five or six to deliver with students. Each session requires students' sheets, notes and materials for the tutor, health and safety documentation and assessment criteria. The new sessions will follow the model which has been shown to work.

Plymouth are also exchanging ideas and materials with the Dublin Institute of Technology.

C4 University of Hull

Introduction

Similar to the situation of Plymouth, staff at the University of Hull have been delivering courses via the CBL/PBL approach since the late 1990s and received financial support at this time to develop materials which are being used now. The CBL/PBL approach is being used within full-time, part-time and distance learning chemistry, pharmaceutical science and foundation year courses and is now well embedded within the curriculum. Working together in groups, students take part in extended activities over 4-6 one hour sessions and also work together in between sessions to gather data and prepare reports. CBL/PBL approaches are a core part of teaching at Hull and evidence collected over the last seven years suggests that students become familiar with this style of learning early on which helps them to gain more from the course. The project lead at Hull feels that one-off activities would be less successful.

Like at Plymouth, CFOF funding is primarily being used to undertake a systematic evaluation of CBL/PBL approaches and to gather evidence to demonstrate the value of this approach in the delivery of chemistry courses. Primarily qualitative data has been collected via student questionnaires, which they complete following activities, and through interviews with delivery staff.

Activities undertaken

The Universities of Hull and Plymouth have worked together for a long time in developing CBL/PBL approaches within chemistry courses and materials have been continually tweaked and enhanced in response to feedback gained. Together, through two different projects, these two universities have developed nine case studies covering applied areas within chemistry. Many of these (which are described in more detail in the section on the University of Plymouth) have been used at Hull as part of the Strand 3.2 CFOF project as detailed below:

- Chemistry foundation year: ‘The Pale Horse’ (forensic analysis) and ‘New Drugs for Old’
- Year 1: ‘The Titan Project’ (full-time chemistry students); and ‘New Drugs for Old’ (full-time pharmaceutical science students); ‘Between a Rock and a Hard Place’ and ‘Chemistry in Sport’ (part-time chemistry students)
- Year 2: ‘The Pale Horse’(full-time and part-time chemistry students); ‘Chemistry in Sport’ and ‘Between a Rock and a Hard Place’ (part-time chemistry students)
- Year 3: ‘The Pale Horse’ (full-time chemistry students).

Another CBL/PBL case study in descriptive inorganic chemistry published by the RSC is also to be used with part-time foundation degree students to cover the chemistry of silicon and as part of a 6th form enrichment programme.

Introduction to the evaluation

Student and staff perceptions of the CBL/PBL approach to teaching and learning have been investigated through the use of semi-structured questionnaires and focus group discussions. Several groups of students engaged with context based learning in a classroom environment. These were year one full-time chemistry students ('The Titan Project' case study) and year two full-time chemistry students ('The Pale Horse' case study), who completed the questionnaire, and year one full-time pharmaceutical science students ('New Drugs for Old' case study) who took part in a focus group. Students were asked about: the advantages and disadvantages of the approach over traditional lectures; how they felt about learning chemistry in this way; what chemistry they had learned; what skills they had developed and whether they thought they would be needed in a future career; what improvements could be made to the activity; and whether they felt the assessment methods were appropriate.

The year one part-time chemistry students completed a module through web-based independent learning ('Between a Rock and a Hard Place' on Blackboard and 'Chemistry in Sport' on the departmental website) and the year two part-time chemistry students completed 'The Pale Horse' case study via Blackboard. These two small groups of students answered the questions above as well as three additional questions related to the online aspect of their studies. These included: how they found using Blackboard for the course; how the course has compared to other courses and how using Blackboard has helped their performance.

The tutors of the classroom-based sessions gave recorded interviews in response to questions on: the advantages and disadvantages of using case studies over traditional lectures; what they thought about teaching chemistry in this way; how students reacted to this type of teaching/learning; what chemistry they thought students had learned; what skills CBL/PBL helped students to develop; whether they felt these skills could be transferred into a work/research environment; what improvements/changes could be made; and whether the methods of assessment were appropriate.

The responses from all of the questionnaires and interviews were transcribed, collated and analysed. Analysis of the responses for each question showed that a number of themes recurred within each case study group. The next section discusses the analysis of each group individually followed by a summary of the most common themes from the evaluation as a whole.

Evaluation of CBL/PBL within chemistry degrees: student responses

‘The Pale Horse’ case study: year two full-time chemistry students and year two part-time chemistry students

Twenty-four year two full-time chemistry students undertaking ‘The Pale Horse’ case study completed the questionnaire. Responses in relation to the advantages of this learning over traditional lectures focused mainly on the teaching style and the method of learning that this created. Five main themes were identified. The development and application of skills was mentioned (n = 18) with problem solving, communication and decision making being the skills most often identified. Students’ comments include: ‘*We were made to think and make our own minds up as to what the answer was and why*’ and ‘*We are given a chance to think, rather than just accepting what we are presented with*’. Another common theme was their level of interaction and involvement with the subject matter as well as with the tutor and one another. Comments include: ‘*It’s a lot more hands-on rather than an hour of being talked to. Understanding comes from discussion rather than hours of books’.* The students also found this type of learning more interesting and enjoyable. As two students comment: ‘*Very fun/enjoyable*’ and ‘*More interesting*’. Applying new and existing knowledge was also seen as an advantage: ‘*The ability to make our own decisions allowed us to put our subject knowledge into practice and see how it could be used in a real life situation*’. The teamwork/group work aspect of the case study was also seen to be beneficial, allowing discussion that led to greater retention of the subject matter as well as the acceptance, verification and reinforcement of ideas: ‘*Gives the opportunity to discuss things within groups, which means we may find solutions to problems we may not have thought of by ourselves*’.

Students’ responses in relation to the disadvantages of this type of learning over traditional lectures centre on concerns regarding the lack of guidance from the tutors in relation to the learning material as well as doubts about the amount they are expected to learn (n = 13). As two students comment: ‘*Sometimes you need a guideline to work and some basic rule to follow*’ and ‘*A lot is down to what you pick up – you may not learn everything needed*’. Group dynamics are also a concern, particularly in relation to students in groups who do not contribute. As two students comment: '*Unreliable people in your group*' and '*Some people tend to sit there and do nothing*'. Seven members of the class saw no disadvantage in this teaching method.

Regarding the question in relation to what students thought about learning chemistry in this way, most students (n = 14) commented on how interesting and enjoyable they had found the experience. Examples of positive comments include: '*It would be better. It would make me turn up to more lectures', 'I enjoyed it. The chance to discuss and debate with my peers about a range of subjects I find satisfying and interesting*', '*Enjoyable*', '*I found it enjoyable as I had to apply chemistry to a problem to gain an answer*' and '*More interesting*'. Nine students focused on both positive and negative aspects of the learning process. Some felt that CBL/PBL was suitable for certain topics ('*Good for certain projects that are more problem based*') whilst a minority felt that they would prefer lectures at this stage of their education: '*I think at this stage of education it is not enough, we must have a proper lecture*'.

'The Pale Horse' case study is about a forensic investigation so, as might be expected, eleven students mentioned analytical methods and techniques when asked what they had learnt from the case study. Comments include: '*More about what chromatographic techniques can be used for different applications*', '*What are the correct machines to use in analysing samples. How to interpret data*' and '*How various spectroscopic techniques are employed*'. Six of the students mentioned topics related to the context of the case study rather than the actual chemistry presented within. Comments include: '*Police investigations/forensics*', and '*Learnt deductive techniques and how to prioritise/decide between money and accuracy*'. Rather than focusing on the chemistry, five students focused on the skills they had learned during the case study. Three students mentioned the poison used in the case study. Three students did not give a response for this question and two students believed that had not learned much chemistry: '*Not much*' and '*Not too much, more detective and skills work*'.

In relation to the skills they had learned, the main focus of responses was on presentation and communication skills (n =17) and group work/teamwork (n =14). Five students identified problem solving and four students mentioned decision making as skills they had learned. Comments in relation to skills development include: '*Presentation and detective skills, communication skills,* *teamwork, problem solving*', '*Work in group and relate our theory to real problems*', '*How to look at various pieces of data and pick what's important'* and '*Development in logical and lateral thinking*'. Every student answered positively that they would need the skills that they had developed in their future career, showing an awareness of the skills required beyond their degrees.

Eleven students gave no response to a question regarding what improvements/changes could be made to this activity and five students said no improvements/changes were necessary. Five students suggested that more content could be added to the course and others suggested that a selection of case studies would be useful: '*A little more chemistry*', '*A selection of case studies would help*' and '*Longer course, more in depth*'.

In relation to whether they felt that the methods of assessment were appropriate, almost every student thought that assessment of their presentations alongside peer assessment was fair. Students' comments include: *'Yes. Peer reviews help ensure everybody pulls their weight*' and '*I thought they were. No exam stress*'. There were two students not responding to the question and one commented: '*The main assessment shouldn't just be a presentation as some people don't feel comfortable speaking*'.

Overall, the responses to the questionnaire for this group of year two students show evidence of their ability to reflect upon the learning experience.

The responses of the year two part-time students who studied independently via Blackboard mirror those of the full-time students except that these students are in need of more support in the early stages when using Blackboard. As one student comments:

> *Quite handy cos it's all set up for us to communicate on it. With the file exchange and stuff. To be honest we found it quite difficult. Maybe we could just been given summat to go on…either like an introduction to forensic science or like a lecture or something like that…or like a list of books that would be useful. We had to learn as we were going along and only at the end we thought oh we should've asked for that at the start. It's probably similar to how it would be in real life but we had nothing to go on at first. But I think we've done alright now, we've come to some sort of conclusion.*

'The Titan Project' case study: year one full-time chemistry students

Sixty-two year one full-time chemistry students undertaking 'The Titan Project' case study completed the questionnaires. When analysed, the student responses to the question on the advantages that this learning has over traditional lectures fall into six categories. The most common response relates to the advantages of working with groups of other students (n=28). As one student comments: '*Get to work as a team to come up with the best solutions*'. The second most common response relates to interaction and active participation (n=19). Comments include: '*More active due to greater involvement*', and '*It's more informal, there is more interaction, so you participate more and think more*'. Other themes include: skills development, including decision making and thinking skills; independent learning; and appreciation of real life contexts.

Themes identified in questions in relation to the disadvantages of this mode of learning over traditional lectures focus on concerns over the functioning of the groups (n=24), concerns about the amount of knowledge covered (n=15) and the pressure of deadlines (n=5).

When asked what they thought about learning in this way, students were overwhelmingly positive (n=49). As one student comments: '*It makes it more interesting and you are more likely to remember things you have found out yourself and put to use*'. A relatively small number of students were not enthusiastic (n=4). One of these mentions the difficulties of working in a group with people not contributing and lack of confidence in giving presentations: '*I hate it. Having the work spread evenly in the group is hard as there's always lazy people. I'd so much rather hand in a written report than do a presentation. It would make it easier for shy people to gain marks!*'.

When asked what chemistry they had learned, students identified topics covered by the case study. Most students also recognised that they had developed a number of skills including: working in a group (n=40); communication skills (n=28); research skills (n=20); presentation skills (n=12); and problem solving (n=10). None of the students thought that they would not need these skills for their future careers. Most of the suggestions for improvements related to management of the groups. Students were happy with the assessment with just four students expressing concern over the fairness of peer assessment.

‘New Drugs for Old’: year one full-time pharmaceutical science students

Student responses mirror those discussed above. Advantages cited include independent learning and interaction. The only disadvantage identified is uncertainty about content coverage. This case study was also studied independently by part-time students. Their responses are very similar and the marks achieved are also similar.

‘Chemistry in Sport’ and ‘Between a Rock and a Hard Place’: year two part-time chemistry students

This module was studied by independent study by only three students. The analysis of their interviews reveals some common responses. Students felt that the advantages of learning this way over traditional lectures were the real world examples and the opportunity to work at their own pace: ‘*It gives real world examples to some of the material that you learn in lectures*’. The disadvantages related to concerns over covering the appropriate theory (‘*Because sometimes the questions are quite broad, in terms of chemistry you could easily go off on a tangent, in the wrong direction*’) and workload (‘*Trying to fit it in alongside lab write ups and tutorials and with our exams so close to the end of the semester it’s about trying to get everything done so we can revise*’). However, students appreciated the self-directed mode of study and independence. As one student comments: ‘*I think it’s good cos you get to do it by yourself and try and look at it yourself. But obviously you’ll come up with problems if you don’t understand it. It boosts your confidence*’. All students recognised that they had acquired the chemistry intended by the design of the case studies. The skills learned by these students included independent learning, IT skills and research skills.

Evaluation of CBL/PBL within chemistry degrees: staff responses

Analysis of the staff responses reveals several advantages over traditional lectures. These include: more active engagement of students; the development of students’ team work skills; and the development of other generic skills such as communication and time management. Staff have also found the approach more enjoyable to teach than other approaches and report that it has enabled them to have more interaction with students, which has led to them providing better feedback. However, the approach is not seen to be as easy as lecturing. Key disadvantages cited have been the increased time commitment, as students have to be split into groups of about 30, and the fact that some students do not take the approach seriously because it is not assessed by a final examination. Additionally, although most students enjoy the approach, some worry about 'coverage'.

Overview of evaluation findings

Overall, the evaluation has identified several advantages to CBL/PBL. These are all related to the *process* of CBL/PBL. They include: interactive and active engagement of students; independent learning; skills development; and group working. Disadvantages relate to the content i.e. the acquisition of knowledge, concerns over adequate coverage and the difficulties of group work, particularly non-participation of some members. The message here seems to be that, to enhance the effectiveness of context based learning, students need to be supported and given confidence in the information they retrieve. Staff should also spend some time addressing fears over 'passengers' in group work and introduce strategies to ameliorate it.

When CBL/PBL is carried out independently via a VLE, the same issues arise. Additionally, students appreciate the flexibility and independence but feel the need for more support early on in the process.

Future plans

For the extension funding period, the University of Hull intend to take materials that they have been using for a number of years and update and extend them, including adding international examples. In relation to the international dimension, Hull aim to:

- ensure that students understand that the chemical industry is a global industry and not a local industry
- raise students' awareness of the usefulness of language skills. This might be achieved by giving students resources that need to be translated. They are not aiming to teach students languages, but to make them aware that language skills could make them more employable.

These new materials will be developed in the autumn 2008 semester and trialled later in the academic year. This will add value to the existing materials, and internationalisation is a current 'hot' topic in higher education.