National HE STEM Programme - Final Report

Written and compiled by Michael Grove


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UNIVERSITY OF BIRMINGHAM

STEM Education Centre

National HE STEM Programme

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Acknowledgements

The achievements and successes detailed within this report would not have been possible without the Higher Education Funding Councils for England and Wales or the tireless hard work dedication of all members of the Programme Team within the Hub, Spokes and Professional Bodies to establish and support a range of activities and initiatives in fulfilment of the Programme's aims and objectives; they deserve thanks for all of their efforts over the three-years of the Programme. Great thanks are due to Dagmar Waller and Daryl Davies for their help and support that enabled the Programme's concluding conference to run successfully in September 2012 and for their help in the production of this final report; thanks also to Chantal Jackson for her design and layout of this report. Finally, the activities of the Programme were undertaken by those based within the higher education sector within a range of higher education institutions; the National HE STEM Programme is grateful to all those involved in each project for their hard work and dedication, and their ongoing commitment to enhancing all aspects of the STEM student learning experience.

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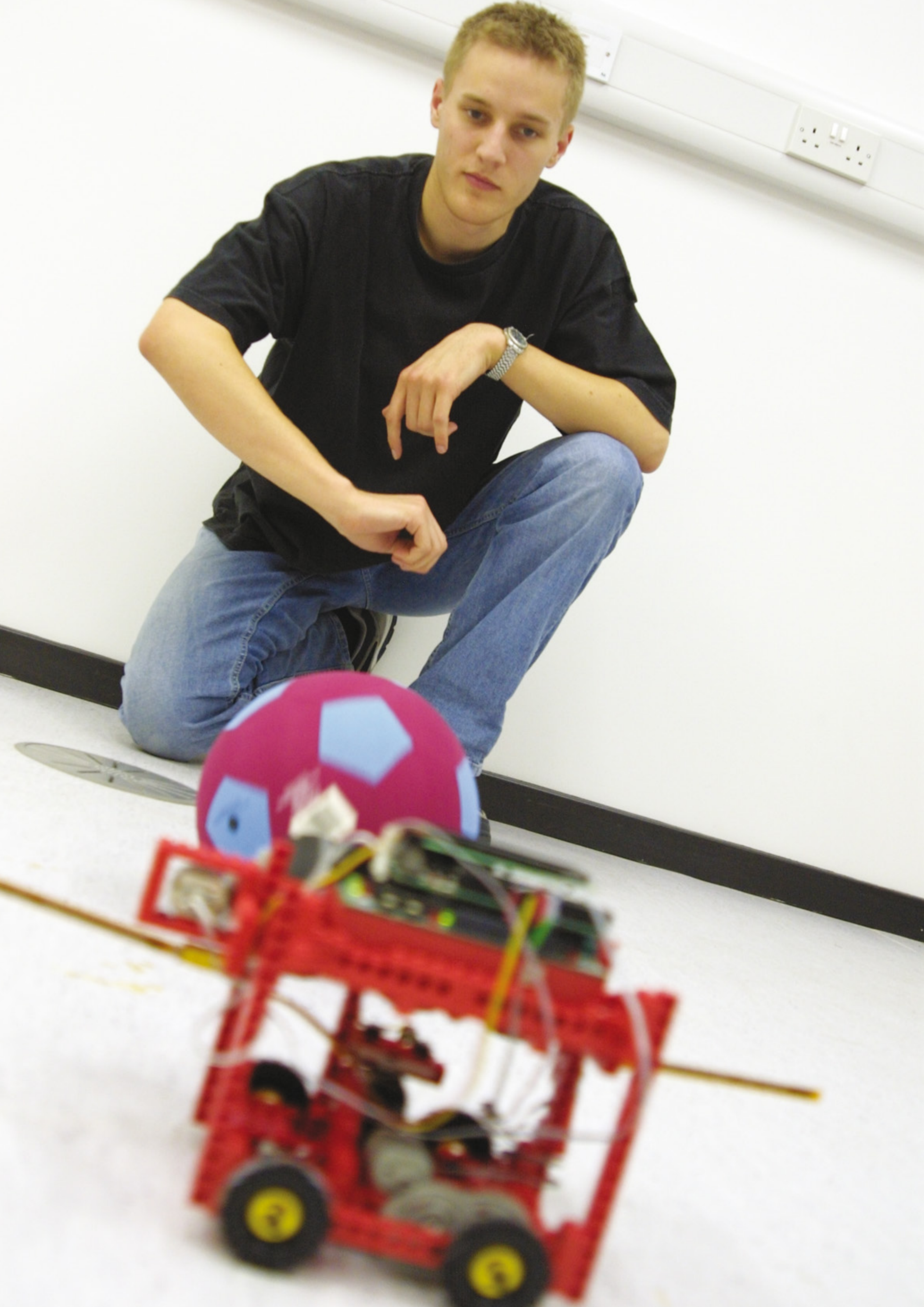

Section 1
Executive Summary

1. The National HE STEM Programme formed a three-year initiative, funded by the Higher Education Funding Councils for England and Wales, designed to enhance the way universities recruit students and delivery programmes of study within the STEM disciplines of chemistry, engineering, mathematics and physics.

2. The Programme was set a challenging remit. It needed to integrate four previously successful pilot projects, all of whom were highly regarded by their disciplinary communities, and embed their activities firmly within the practices of universities. At the same time it needed to maintain the higher education STEM sector's focus upon the importance of continuing to widen participation and take forward a new agenda relating to higher level skills, not only for those who were soon to graduate, but also for those currently within the workplace. Furthermore, the Programme needed to ensure its activities were higher education specific, added value, and did not duplicate those of already existing STEM initiatives and organisations. Finally, the practices and approaches it developed needed to be sustainable in order that they could live on within the higher education sector for years to come.

3. In response the Programme set itself a challenging series of objectives. Its approach to fulfilling these involved firmly embedding its work within the higher education sector and seeking to do so through changed curricula and practice. At the core of its delivery model were six Spoke universities and four Professional Body Partners supported by a central Hub at the University of Birmingham. While Professional Bodies commenced the Programme with a defined series of activities, Spokes developed their work in conjunction with their regional higher education institutions to meet identified needs and priorities.

4. In undertaking the Programme's work, engagement has been extensive. Ninety higher education institutions have participated through a range of projects, over eighty have led them. Higher education staff, postgraduate students and undergraduates have participated in projects, workshops and professional development events; over 300 higher education representatives attended the Programme's concluding conference in September 2012. While universities have led projects, a range of employers, charitable organisations, STEM initiatives and organisations and other stakeholders have been engaged and actively participated.

5. The impact of the Programme's work is only now becoming increasingly evident. Embedding changes to university curricula and practice do not manifest themselves immediately, but there is an increasing body of evidence, both internal and external to the Programme, that indicates not

only has significant change been achieved but it exists in a sustainable manner. Furthermore, there is emerging evidence that the practices and approaches established by the Programme are now having a wider influence beyond those individuals and departments who have engaged.

6. This is not to say that the implementation of the Programme has been easy, it has faced a number of challenges. The Programme has operated in a changed economic, educational and political landscape, all of which have influenced its work. The Programme was a large initiative to establish and the lack of a dedicated start-up period had a number of knock on effects which shortened the time over which it was able to deliver its activities. Changing practice within the higher education sector is a longer term process; it takes time to achieve and even longer to evidence. As such, the Programme faced challenges throughout in articulating the impact its work was having.

7. Nevertheless, the Programme has achieved its original aim and objectives. It has embedded the activities of the four disciplinary pilot projects within the higher education sector, stimulated a range of new developments and practices, including new STEM modules and programmes of study, and transferred effective practices more widely. A legacy for its work remains, in terms of both the activities and changed practices it has embedded, the networks that have been established, and the commitment of the Hub, Spoke and Professional Body Partners to continuing the Programme's work long into the future.

Objective 1: To develop infrastructures which enable the Higher Education and employment sectors to offer a collaborative and sustainable supply of life-long-learning opportunities to support the UK workforce from school, during university and within the workplace.

8. Over the course of the Programme activities took place across three linked strands with widening participation underpinning each: universities have been supported to work more effectively with those in the school and college sectors; curriculum revisions undertaken with an emphasis upon student knowledge, progression and skills; and members of the UK's workforce engaged to develop enhanced knowledge and skills. In year one, the Programme built upon the work of the pilot projects, in year 2 it initiated new developments, while in its final year it transferred and embedded these developed practices more widely.

9. By engaging with the Programme, universities have adopted effective practices and approaches to working with schools and colleges, firstly from those developed by the four disciplinary pilot projects, and latterly those developed by other higher education institutions within the Programme; employers have had a role in contributing to delivery. Ensuring the appropriate targeting of outreach activities in order that they benefit widening participation cohorts has been achieved, either by departments working with their central institutional teams or by working in partnership with existing STEM organisations and initiatives. Staff and students have been recruited as STEM ambassadors and training mechanisms established to enable the recruitment of future cohorts. Professional development opportunities have been offered and undertaken, as a result staff report they feel more confident working with certain groups of learners.

10. The Programme recognised that transitions were important, from school or college to university, and from university to the workplace. Activities were focused around these key transition points to recruit, support and equip students with the skills and knowledge needed to be successful in their studies or their future careers. In moving from school to university, key problem areas, such as mathematics, laboratory skills, and enabling students to become more effective independent learners have all been tackled.

11. Significant changes have been made to the higher education curriculum. Employers have worked with universities to advise on curriculum changes and support their implementation, SMEs have been effectively engaged. There are now increased instances of employers contributing to the delivery of the curriculum, supporting learners, and offering experiential learning opportunities, placements and projects. Learning and teaching methods have been reviewed and changed to allow increased opportunities for students to develop and articulate their skills. Following curriculum innovations, early student feedback indicates they have been valuable, not only in developing skills, but in securing opportunities within the workplace.

12. New full and part-time programmes of study in chemistry, engineering and physics have been created, and a range of flexible short courses and more bespoke options have been developed to enable those currently within the workplace to engage in university level learning. Although still in their early stages, students have been recruited and have engaged with this newly established provision. Through the relationships universities have developed with employers there have been unexpected benefits, including opportunities to provide additional short courses and interactions that have extended to the full-time curriculum. Through its work the Programme has been able to demonstrate the benefits to universities by engaging collaboratively with employers.

Objective 2: To develop innovative and transferable models and programmes of activity across the disciplines of Chemistry, Engineering, Mathematics and Physics, relating to access, skills development and employer engagement through the integration and strategic development of existing activities, initiatives and resources, that will offer demonstrable long-term benefit to the Higher Education sector.

13. Building upon effective practice was a key feature of the Programme's design, implementation and operation. During its development phase, a range of approaches and practices that had previously proved successful through the pilot projects were identified. While a number were ready for immediate roll-out, others needed a period of 'packaging' to present them in an accessible format. Through a variety of mechanisms these activities were rolled out and have become embedded as part of the practice of universities. Their embedding has been achieved in differing ways. In some they now exist as standalone activities forming part of an institutional offering or have been incorporated into residential events. In others, they have been combined with existing activities to allow students to achieve awards or form a programme of activity during National Science Week.

14. By undertaking its work at national, regional and disciplinary levels the Programme has been able to identify effective practices and approaches and design activities to build upon these. Programme Partners worked as brokers, encouraging and supporting higher education staff to engage in dialogue, share their approaches, and collaborate to develop them further.

15. The further development of existing effective practices, across all strands of activity, has not only allowed more universities the opportunity to benefit, but it has enabled these benefits to be achieved in a more cost effective manner. The relationships established continue to develop; universities who had not previously collaborated are now working together on the joint delivery of outreach activities, sharing equipment and resources, and working together on curriculum developments and the implementation of new degree programmes.

16. Building upon effective practices has allowed approaches and ideas to be transferred between disciplines, and contributed to innovative or integrated developments. Interactive outreach approaches have now been further developed within physics and the mathematical sciences, regional approaches to engineering outreach established, and professional bodies are collaborating to encourage students to pursue careers in teaching.

Objective 3: To broker and facilitate the community-wide sharing and dissemination of good practice in relation to Higher Education STEM activities, education and employer engagement.

17. The sharing of practice has been widespread throughout the Programme with dissemination forming a core part of its work. Events and workshops have been held nationally, regionally, and within individual higher education institutions forming an important means of raising awareness of the Programme, sharing learning and findings, and disseminating the publications, resources and toolkits that have been developed; they also acted as an important focus for networking and developing collaborations. Where the success of the Programme is most evident, however, is in how it extended the nature of 'dissemination' to encompass 'uptake'; that is, it established mechanisms

that have proved particularly effective at enabling approaches developed in one university to be adapted and transferred to another.

18. A series of innovative approaches have been introduced. The Menu of Activities offered pump-priming funds, implementation guides, supporting materials, and access to the expertise of those who had previously undertaken the activities, as a means of transferring and embedding the practices and approaches developed by the pilot projects. Eight large-scale partnerships transferred and embedded effective practice in key strategic areas where there was an identified need, and 'seed funding' was made available for the implementation of approaches presented at workshops or contained within Programme publications. All proved effective at achieving their intended goal of enabling uptake.

19. The most innovative scheme established was the Practice Transfer Adoption initiative. Through this the leads of successful projects made their work available for 'adoption and adaption' by other universities; over 80 Programme developed practices have been transferred between universities in this way. This approach demonstrated it was effective at sharing practices between individuals who had not worked together previously, often then engaging them in new networks or communities, and at transferring approaches across disciplinary boundaries.

Objective 4: To establish a culture of sustainable collaboration within the national Higher Education STEM sector by working in partnership with HEIs, employers, professional bodies, and existing and future initiatives and organisations.

20. A strong track record of collaboration and shared working exists within the higher education STEM sector and this has been furthered through the Programme. While it perhaps might have been expected that in the changed higher education 'landscape' of recent times this culture may no longer hold true, the Programme has shown that not only are collaboration and sharing perhaps stronger than ever, it has also been able to demonstrate the benefits to higher education institutions in doing so.

21. Collaboration has been embedded throughout across all strands of activity; over 80% of projects have involved collaboration to some degree, and several have involved collaborations involving all universities within a region. Collaborations have developed between individuals and universities who have not worked together previously, and opportunities for joint working have been enabled with those outside of the higher education sector, including a range of employers, STEM organisations and initiatives, and those within the third sector. The approach adopted has been one of inclusion, individuals without prior experience of leading projects have been able to, in doing so, they have been supported by those who are more experienced.

22. Engaging with existing networks and communities offered real added value to the work of the Programme and the potential to embed and enhance its activities. A particular success has been its work with existing STEM organisations. Here, the support of the National STEM Centre was critical to integrating the Programme into existing networks and allowing collaborations to develop.

23. Collaboration with STEMNET has occurred across all Programme regions. Staff and student ambassadors have been recruited and trained, and universities have engaged with STEMNET STEM Clubs to enable sustained opportunities for working with hard to reach cohorts to be embedded. Working with the Regional Science Learning Centres provided opportunities for the

professional development of higher education staff, networking with schools and colleges, and the use of high quality facilities for use within university led outreach activities.

24. Collaborations at a local level will be sustained, in many instances, universities have committed to growing and developing these. At a national level networks have been established based around the activities undertaken and where common interests exist. In some instances they will continue to be supported by the Programme's Professional Body Partners, in others they will be self sustaining as the benefits of collaboration are evident to those involved.

Objective 5: To act as a catalyst for institutional change so that the National STEM Programme may be embedded within the Higher Education sector to create a long-term and sustainable programme of activity.

25. The manner in which the Programme has undertaken its activities has resulted in an increasing body of evidence that the majority of its activities will be sustainable, and as such the developed practices and approaches will continue beyond the end of its funded lifetime. Sustainability has been at the heart of the Programme, through project design, implementation, and monitoring. All projects were required to articulate approaches to sustainability at their outset, and their progress towards it monitored. Across the entire Programme sustainability was reviewed and resources refocused towards sustainable approaches with demonstrable impact. Programme staff were key; they supported projects throughout by exploring sustainability models and options and brokered opportunities for sustainability to be realised.

26. Not all activities will be sustainable in their current form. Some have been modified, while others have contributed to more widespread changes within their respective higher education institutions. For many projects a legacy will exist amongst the staff who have engaged; the knowledge, expertise and contacts they have developed will ensure the legacy continues through their future work.

27. There also exists increasing evidence that project leads are now building upon their work, either through additional developments, or by the wider roll-out of practices across a faculty or university to encompass new programmes of study or discipline areas. A number of projects have either acquired additional funding to extend their work; others have indicated an explicit intention to do so.

28. One question remaining currently unanswered is the extent to which the Programme has resulted in wider cultural change within universities. The Programme has brought about change within institutions, but a further question needs to be asked whether it was realistic for the Programme to be expected to bring about wider cultural change, particularly given its focus upon four disciplines and three-year timeframe.

29. There are examples of the Programme exerting a wider influence than expected upon the practices, approaches and processes of higher education

institutions; as such, has the Programme started to stimulate wider culture change which may not manifest itself fully for some time? To bring about such change there needs to be a 'critical mass' of staff and they need to be supported by senior management; both groups have been engaged significantly through the work of the Programme.

Objective 6: To develop an efficient, effective and adaptable programme of national activity that responds to emerging sector needs and national policies and offers a high quality experience to all who engage with it.

30. The Programme has needed to adapt and modify throughout its three-year period of operation. The changing educational, economic and political landscape has forced ideas and approaches to be rethought. National priorities at the outset of the Programme appeared to change, and the Programme needed to refocus its work accordingly to ensure its original goals were maintained.

31. The lack of a dedicated start-up period meant many activities needed to be undertaken simultaneously and limited the time available for their implementation. Similarly the loss of a range of existing organisations with whom both the Programme and its projects had committed to working with posed real challenges, particularly towards its conclusion when trying to manage the dissemination of learning through activities and events. Similarly, the challenges of seeking to establish a new, and nationally distributed team should not be underestimated, particularly with the need for immediate delivery to be achieved.

32. Despite these challenges, the Programme achieved exactly what it set out to: enhance the way universities recruit students and deliver programmes of study within the STEM disciplines. Key to this success has been its delivery model and the work of its partners who have operated in an open and inclusive manner to engage universities with the Programme's work. Individual project leads have been critical to the success that has been achieved, they demonstrate the undoubted commitment of the UK's higher education STEM sector to ensuring a higher education system that is inclusive, supportive and innovative when working with current and future generations of STEM learner.

Section 2:
Introduction to the Programme

Introduction

1. In August 2009 the National HE STEM Programme commenced its three-year programme of activity within the higher education Science, Technology, Engineering and Mathematics (STEM) sector across England and Wales. The origins of the Programme had however begun some four years previously with a series of discipline based interventions established by the Higher Education Funding Council for England (HEFCE), and in 2008 the decision was taken to integrate these activities into a larger programme for wider national roll-out.

2. This section seeks to provide an overview of the background to the Programme, the development of its activity proposal, a description of its approach to delivery, and any key changes that have resulted to its overall approach since it was established in August 2009. Reflections upon this approach to delivery, from all partners and including key findings and recommendations are discussed further within Section 11 of this report.

Background to the Programme

3. In 2004, the Secretary of State sought advice from HEFCE on strategically important, but vulnerable, higher education subjects or courses. A review was undertaken to identify subjects in need of support to address an imbalance between supply and demand, and a range of disciplines were identified including chemistry, engineering, mathematics and physics. These were all subjects where participation had been falling steadily over a number of years.

4. In response to the findings from the review, HEFCE in 2005 invited the Royal Society of Chemistry (RSC), the Royal Academy of Engineering (RAEng), a consortium of mathematical bodies led by the Maths, Stats & OR Network (MSOR), and the Institute of Physics (IoP), to explore possibilities for profile-raising pilot activities in these disciplines that would encourage increased applications at degree level. Four programmes of disciplinary activity: Chemistry for our Future; The London Engineering Project; More Maths Grads; and, Stimulating Physics, were funded that undertook a range of evaluated discipline-based interventions that were specifically designed to increase demand for, and to widen participation within, their respective disciplines in higher education. While all projects had formally started the deliveries of their activities only within England in 2005/06, in 2008, all four projects were invited by the Higher Education Funding Council for Wales (HEFCW) to develop proposals to extend the reach of their activities into Wales during 2008/09.

5. When the last of these four pilot projects completed its work in January 2010, they had undertaken a range of activities and projects within their respective disciplinary communities and much learning had been generated. While many of the interventions had been proven successful, they had taken place on a limited pilot scale across England and Wales and a mechanism was needed for ensuring this learning was transferred more widely and with a higher education specific focus. While the four projects were continuing to operate, the decision was taken to roll-out the activities from the pilots as part of an integrated National HE STEM Programme that would commence in August 2009, but which would also have a wider remit to address the then Government's higher-level skills agenda.

6. On the 4 November 2009, a call was issued inviting higher education institutions with sustainable[1] provision in the disciplines of chemistry, engineering, mathematics and physics to submit tenders to host the National HE STEM Programme for a period of 3 years (from 1 August 2009 to 31 July 2012) and develop a proposal for its £20million activity within England[2] that was to be submitted to HEFCE for consideration by its Board in March 2009.

7. In addition to a challenging timescale for the production of a full activity proposal for the Programme, an equally challenging remit was also set for how the Programme needed to operate and deliver its activities, and in particular how it would need to interface with existing STEM organisations and initiatives. Recognising the range of work being undertaken by the (then) Department for Children, Schools and Families and its national STEM programme, and broader changes in the HE policy landscape, HEFCE stipulated:

> **"These two policy environments mean that the HE STEM Programme will need to rationalise and prioritise the activity undertaken with schools and colleges to that which is HE-specific and brings real added value. It will also need to embrace the evolving agenda for HE that is more flexible and responsive both to the needs of employers and of employees." HEFCE, Circular Letter Number 30/2008 (2008)**

8. It was also essential that the National Programme built upon the successes and achievements of the four disciplinary pilot projects, and involved those who had undertaken and overseen their delivery:

> **"Also key to the development of the national programme is the need to build on the successes of the existing pilot projects and retain the expertise and knowledge that they have generated. Consequently, we are keen to ensure that the organisations currently delivering the projects play a significant role in the development and subsequent delivery of the programme." HEFCE, Circular Letter Number 30/2008 (2008)**

[1] Defined to be a minimum of 30 full-time equivalent students registered on an eligible award within a relevant cost centre.

[2] At this stage, HEFCW had not formally agreed to participate in the fully developed Programme.

9. Additionally, and perhaps most significantly, the importance of longer-term sustainability was embedded at the Programme's outset:

"HEFCE will not be able to provide special initiative funding for this activity indefinitely. There is therefore a need for the national programme to develop a sustainability strategy that firmly locates the work it undertakes within HEIs." HEFCE, Circular Letter Number 30/2008 (2008)

Pre-Programme: Tendering and Proposal Development Phases

10. Proposals to host the National HE STEM Programme were required to be submitted to HEFCE by noon on Friday 28 November 2008, and following a competitive review process, the University of Birmingham was informed it had been successful in securing hosting of the Programme in early December 2008. The University's intent for the development of the activity proposal to be an inclusive one involved the establishment of external Executive and Advisory Groups, involving Professional Body representatives, to oversee and steer the development of the proposal, and significant consultation with the STEM community through a series of regional focus groups, and an open call for written evidence and ideas. Such an approach was adopted with a view to obtaining buy-in to the Programme at its outset, and identifying both effective practice and potentially willing partners. Further work was undertaken with Professional Body representatives involved with the pilot projects outside of committee meetings to develop and distil ideas and proposals for activities to be taken forward into the integrated Programme.

11. It is unclear how many HEIs submitted proposals to host the Programme, however it became quickly apparent there was some disquiet across the sector with the decision to award hosting of the Programme to the University of Birmingham, and this, at times, had a somewhat negative influence during aspects of the proposal development phase. Indeed, there exists evidence that, in some quarters at least, negativity towards the Programme continued throughout its first year of operation, as noted by the Funding Councils for England and Wales in a paper submitted to the Programme's Executive Committee in June 2010, which did prove a distraction to the Team trying to initiate and oversee delivery:

"Furthermore, given the controversy surrounding the programme…"HEFCE/HEFCW Executive Committee Paper (June 2010)

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12. Nevertheless, the submission of a full and detailed activity proposal, signed off by all four Professional Bodies and both the development phase Executive and Advisory Committees, was made to the Funding Councils on the 20 March 2009. A particular change from the specification for the Programme as defined in HEFCE's 2008 Circular Letter was the decision for the Welsh Funding Council to participate in the Programme in order to enable its activities to be extended into Wales; this was supported by additional funding which increased the Programme's budget to £21 million.

13. The submitted proposal defined an overarching strategy for the Programme, a delivery model, and a plan for a phased series of activities. The proposal recognised that while the delivery of some activities could take place immediately, in particular the transfer and embedding of specific pilot project practices which were explicitly built-into the proposal, other activities would need to be 'phased in' following a development period; this was particularly true for the higher-level skills

strand of the Programme. The proposal document did not therefore provide a definite plan for all of the Programme's activities, but more a framework by which the Programme would operate.

14. The University of Birmingham received notification that the proposal for the Programme had been successful on the 8 May 2009, but due to pre-election purdah, and the need for clarification around points raised by HEFCE's Board Members, an announcement of the Programme could not be made until the 15th June 2009 when work on implementing the mechanisms to enable delivery of its aims and objectives began in earnest.

Aims and Objectives

15. The proposal submitted to the Funding Councils established the aim and objectives for the Programme (Box 2.1).

Aim

To contribute to the development of a national Higher Education STEM sector which:

- **Engages collaboratively to increase and widen participation,**
- **Promotes, supports and champions the STEM disciplines, and**
- **Is increasingly responsive to the skills needs of both employers and employees**

In order to support the development of a strong, diverse and sustainable workforce that will meet the economic needs of the UK for the 21st century.

Key objectives designed to support achievement of this aim are:

1. To develop infrastructures which enable the Higher Education and employment sectors to offer a collaborative and sustainable supply of life-long learning opportunities to support the UK workforce from school, during university and within the workplace.
2. To develop innovative and transferable models and programmes of activity across the disciplines of Chemistry, Engineering, Mathematics and Physics, relating to access, skills development and employer engagement through the integration and strategic development of existing activities, initiatives and resources, that will offer demonstrable long-term benefit to the Higher Education sector.
3. To broker and facilitate the community-wide sharing and dissemination of good practice in relation to Higher Education STEM activities, education and employer engagement.
4. To establish a culture of sustainable collaboration within the national Higher Education STEM sector by working in partnership with HEIs, employers, professional bodies, and existing and future initiatives and organisations.
5. To act as a catalyst for institutional change so that the National STEM Programme may be embedded within the Higher Education sector to create a long-term and sustainable programme of activity.
6. To develop an efficient, effective and adaptable programme of national activity that responds to emerging sector needs and national policies and offers a high quality experience to all who engage with it.

Box 2.1: Aims and Objectives of the National HE STEM Programme

16. The aim and objectives were strongly focused upon the higher education STEM sector and in particular the disciplines of chemistry, engineering, mathematics and physics. Objective 5, however, refers to the Programme acting **"as a catalyst for institutional change"**. This objective was never intended to imply that the Programme alone would result in large-scale institutional changed practices, particularly given the focus upon four disciplines which might form an overall small part of the provision of an institution, and its timeframe of operation. Practice change within the STEM disciplines was a clear objective, but objective 5 was intended to demonstrate that sustainable approaches to activity delivery could be embedded within the higher education sector; as such, the approach of the Programme was to act as a model for sustainable delivery. Nevertheless, evidence has emerged of the Programme exerting an influence beyond the disciplines of chemistry, engineering, mathematics and physics within some higher education institutions.

17. To enable delivery of this aim and objectives the model developed for the Programme was one that aimed to support higher education institutions in the exploration of new approaches to recruiting students and delivering programmes of study within chemistry, engineering, mathematics and physics, and one that would enable the development and transfer of best practice across the higher education STEM sector and facilitate its wider adoption. The natural focus for the Programme was working with, and within, the higher education STEM sector and this approach very deliberately chosen in order to achieve the longer-term sustainability of activity that was critical for the Programme's success and to ensure that all activities maintained a HE specific focus. In particular it was recognised that activities had to be owned by individual higher education institutions if they were to become embedded within their core practices.

18. Underpinning the delivery model was a core focus upon enabling the sector to better encourage and support students participating in higher education from non-traditional backgrounds, and enhancing the skills and knowledge base of the global workforce. Widening participation was at the heart of the work of the entire Programme, and it sought to support higher education institutions enhance their practices when working with groups of learners not traditionally well

represented within the STEM disciplines in higher education, be they currently within school, college, university, or the workplace.

19. To achieve this holistic approach of considering the progression of students from school, through university, and into the workplace, the work of the Programme took place through three interconnected strands (Box 2.2).

1. Widening participation within the STEM disciplines at university level, by supporting HEIs to work with those currently within the school and FE sectors;
2. Higher education curriculum developments focusing upon course delivery and design and student support, to enhance student knowledge, progression and skills;
3. Encouraging those currently within the workforce and society to engage with further study to develop enhanced knowledge and skills.

Box 2.2: Strands of National HE STEM Programme Activity

At its outset the decision was taken for the Programme itself to not engage in the direct delivery of activity within these strands. The rationale for this was strong as it was recognised that there had previously been numerous examples in the past of activities that have had achieved enormous impact, yet when funding ceased, the activities themselves also ceased. Instead the Programme sought to initiate and enhance higher education centred activities by encouraging the development and sharing of practices that could then be transferred between institutions and subsequently embedded as a sustainable part of the core practice of higher education institutions.

20. In a similar vein, in the earlier stages of the Programme a further seven principles were identified (Box 2.3). Recognising that delivery of the Programme's aim and objectives across three strands and within a three-year timeframe would require a significant number of activities to be established, the intent of these core values was to help provide a greater clarity focus to the direction that needed to be taken by the activities if the Programme were to fulfil its aim and objectives.

1. HE focus – activities focus upon supporting and enhancing the short to medium term practice of higher education institutions, but always with a view to enabling longer-term sustainability.
2. Evidence informed practice – where possible, the Programme builds upon existing proven practice.
3. Sustainability – all activities have potential for sustainability in the longer-term.
4. Institutional change – the Programme itself chooses not to focus upon direct delivery. It focuses upon enabling and supporting changes in institutional practices.
5. Collaboration – activities are built around partnership and collaboration, both within and across the STEM sectors.
6. Value-added – the activities of the Programme do not duplicate those of others, but work to bring added value to the higher education sector.
7. Sharing – Programme outputs and resources are made freely available to the higher education sector.

Box 2.3: National HE STEM Programme Core Values

21. While all seven core values were important, a particular feature of the Programme was upon ensuring its activities did not duplicate those of existing STEM organisations and initiatives in what was, and remains, a very complex and crowded landscape:

"There is a need for greater co-ordination and joining up of the many providers of professional development and enhancement activities to achieve more coherent delivery, but without sacrificing diversity of choice." STEM Programme Report, (2006)[3]

During the development phase of the Programme, the University of Birmingham worked closely with the National STEM Centre in York to ensure the proposal complemented existing STEM sector activity[4], and this positive working relationship continued throughout the three-year duration of the Programme.

22. The approach of the Programme to avoiding duplication, or even worse confusion, involved developing relationships with existing STEM organisations or initiatives and then working collaboratively to broker and establish mutually beneficial activities. Such an approach offered a two-fold advantage: not only did it avoid duplication, but also brokered and facilitated relationships between existing STEM sector organisations and those in the higher education sector who would be undertaking delivery; the intention being to create a longer term way of working within the sector.

Delivery Partners

23. Delivery of the activities of the National HE STEM Programme was designed so that it could be undertaken at national, regional and disciplinary levels, and was undertaken through a 'Hub' and 'Spoke' model. The purpose of such an approach was to allow opportunities for maximum engagement within, and across, the STEM community, particularly with higher education institutions, and to ensure that effective practices could be identified and built upon through the work of the Programme.

24. The University of Birmingham acted as 'Hub', overseeing and initiating national activity and facilitating the flow of information across the Higher Education sector. The 'Spoke' Universities of Bath, Birmingham, Bradford, Manchester Metropolitan, Southampton and Swansea acted as a focus for the delivery of regional activities within England and Wales and worked collaboratively with other regional Higher Education institutions on activities of mutual benefit. At a disciplinary level, RSC, IoP, RAEng, and a consortium of mathematical bodies led by the Institute of Mathematics and its Applications[5] (IMA) built upon their work from the pilot stage projects by undertaking an agreed series of activities to transfer and embed the developed pilot project practices more widely across the HE STEM sector. Additionally, the four Professional Body Partners provided disciplined based expertise and leadership to support the national activities of the Programme.

25. Within the proposal submitted to the Funding Councils, England and Wales were divided into six National HE STEM Programme regions as shown in Figure 2.1a; five within England and one covering the entire of Wales. This differed from the traditional 9 Regional Development Agency (RDA) regions (of England) that were commonly used at the time. The National HE STEM Programme regions did make use of the RDA boundaries, but some regions were merged; for example, the North-East Region of the Programme included North East England and Yorkshire and the Humber. A deliberate choice was taken to limit the Spoke regions to six to ensure that resources were not too 'thinly spread', given a core staffing cost was associated with each region, and to ensure that there were a number of HEIs in each region to act as a 'critical mass' to support interaction and delivery.

[3] http://www.nationalstemcentre.org.uk/res/documents/page/050110114146stem_programme_report_2006.pdf

[4] The National STEM Centre led the (then) STEM Cohesion Programme which was created as a means of bringing together the many stakeholders who support the teaching and promotion of STEM subjects.

[5] The mathematics strand was originally scheduled to be led by the London Mathematical Society but this changed to the Institute of Mathematics and its Applications in late 2009.

26. When the Programme commenced, it became clear that the original 'East, South East and London' region was too large and geographically distributed for a single Spoke, and so an agreed decision was taken to extend the remit of the Midlands Spoke into East Anglia, and have a Spoke that covered London and the South East (Figure 2.1b).

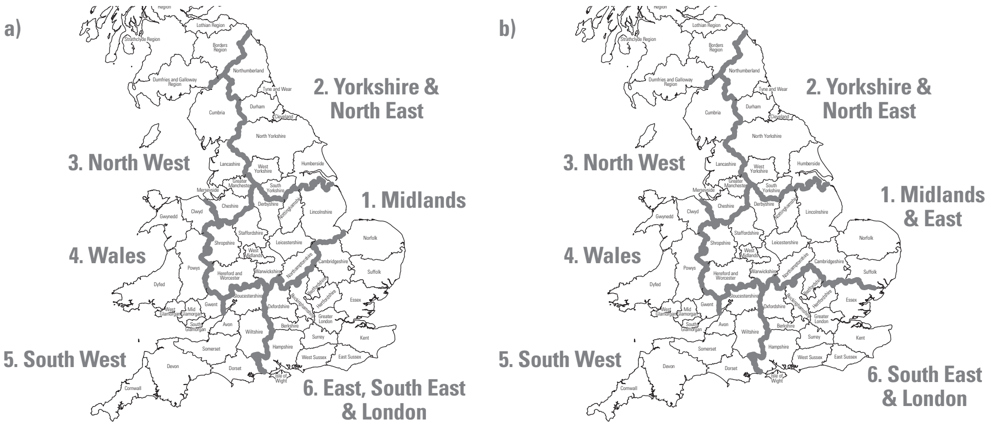


Figure 2.1: National HE STEM Programme Spoke Regions

27. Upon the public announcement of the Programme in June 2009, work commenced to identify the Spoke Universities who would undertake, and oversee delivery within each of the National HE STEM Programme Regions. While some preparatory work to identify potential Spoke HEIs had been undertaken during the bid development phase, it was collaborative discussions with the Funding Councils post June 2009 that helped finalise the list of higher education institutions to be approached and ensured there were a range of differing universities, with differing areas of expertise, participating in the Programme. The University of Southampton was the last Spoke to be finalised in October 2009.

28. During the development of the proposal, discussions with Professional Body Partners had identified a number of other organisations, including higher education institutions, who would actively contribute to the activities of the Programme as delivery partners by working through the Professional Bodies themselves. In engineering and mathematics, curriculum development and enhancement was identified as a priority following the London Engineering Project and More Maths Grads, and so consequently, the then Higher Education Academy Subject Centres for Engineering, and Mathematics, Statistics and Operational Research were engaged to undertake delivery of these respective strands. Similarly, More Maths Grads had identified the importance of mathematics support for enabling progression into, and within, the STEM disciplines, and the **sigma** Centre for Excellence in University Wide Mathematics and Statistics Support at Loughborough and Coventry Universities was engaged to lead this aspect of the Programme's work. Both the Subject Centres and **sigma** not only had extensive prior expertise in their respective fields, but were also well established within their disciplinary communities; as such they provided a solid foundation upon which the Programme could build its work, and a platform for national dissemination in the later years of the Programme. In addition, all three organsiations were in receipt of, or had been established as a result of, HEFCE funding. Similarly, for the activities led by IoP, the University of Leicester, London South Bank University, and the University of Salford were re-engaged to continue to develop and disseminate their work on the delivery of the physics higher education curriculum.

Resource Allocation

29. The model of resource allocation for the Programme was defined within the March 2009 proposal submitted to the Funding Councils. It consisted of specific, well defined, and costed activities

(Box 2.4) that would be led by each Professional Body to build upon the work of their respective pilot projects.

30. While the activities to be undertaken by Professional Body Partners were defined at the outset, substantial funding (totalling approximately £7.15million[6]) was allocated to enable sector wide activity during the Programme's three-year funded lifetime within higher education institutions. While a number of these funding streams had a clearly defined purpose, for example collaboration, others required a period of further scoping and development before implementation; this was especially true for higher-level skills, and in particular workforce development which had not been a theme of activity for any of the four pilot projects.

31. The model for the utilisation of these funds was two-fold: a series of national and specific calls targeted around the Programme's three strands of activity, and the drawn-down of funds by Spokes to implement, in particular, higher-level skills activity at a regional level. As the Programme progressed, the proposed uses of these activity funds were re-categorised, as shown in Table 2.1, following discussion at both Programme Board and Executive Committee.

Activity	Chemistry	Engineering	Maths	Physics	TOTAL
Project Officer (Integration, Diversity & Curriculum)	195,000	195,000	195,000	195,000	**780,000**
Project Officer (Integration, Diversity & Curriculum)	195,000	195,000	275,000	195,000	**860,000**
Employer Co-ordinator (Maths based in HEI)	97,500	195,000	275,000		**567,500**
Subject Centre Based Post		300,000			**300,000**
Teacher Fellows: 2 fellows for RSC: (Yr 1), 2 fellows for RSC (Yr 2), Yr 3 rollout	244,000				**244,000**
Maths Support			300,000		**300,000**
STEM Careers			85,000	30,000	**115,000**
Engineering in Society		60,000			**60,000**
Innovation Projects		300,000	300,000		**600,000**
CBL/PBL (2 yrs dev. £133K: 1 yr rollout £50K)	316,000				**316,000**
Employer Engagement Innovation Project	284,000				**284,000**
Re-packaging				350,000	**350,000**
Integrated Sciences				850,000	**850,000**
Ambassadors			100,000		**100,000**
Education research		30,000			**30,000**
STEM Days/STEM Clubs		250,000			**250,000**
Spectroscopy in a suitcase	189,000				**189,000**
Totals	**1,520,500**	**1,525,000**	**1,530,00**	**1,620,000**	**6,195,500**

Box 2.4: Professional Body Activities, Proposal for Funding (2009)

[6]Excluding costs allocated for evaluation, publicity, promotion, marketing & branding.

Funding Stream Name	Purpose	Implementation Date
Collaborative Projects	Establish collaborations building upon effective practice, particularly from the four disciplinary pilot projects.	Spring 2010
Menu of Activities	Transfer and embedding of pilot project activities.	Autumn 2010 & Spring 2011
Large-Scale Curriculum	Curriculum innovation and enhancement at departmental level.	Autumn 2010
Regional Action Plans	Workforce development and graduate skills at a regional level.	Autumn 2010
Legacy Projects	Workforce development and graduate skills within Spoke HEIs	Summer 2010
Practice Transfer Partnerships	Sharing effective practice through collaborative activity.	Summer 2011
Practice Transfer Adopters	Transfer and embedding the outcomes from the National HE STEM Programme	Autumn 2011

Table 2.1: National HE STEM Programme Additional Activity Streams

32. Each funding stream maintained the focus upon enabling fulfilment of the Programme's aim and objectives, and indeed the intent of the original streams as defined within the March 2009 proposal. The most significant variation was modification to the 'Spoke Replication Fund' partly in response to national changes that were taking place across the higher education sectors in England and Wales at the time:

"To ensure that outputs from the National Programme are embedded within a significant number of HEIs by the end of the HEFCE funded period, within year 2, a programme of activity will commence to create around 30 'sub spoke' HEIs, distributed strategically across the regions, and designed to ensure the embedding of practice from the National STEM Programme in a focussed way." National HE STEM Programme Proposal Document, (March 2009)

In its place, the 'Practice Transfer Partnerships' and 'Practice Transfer Adopters' were established to fulfil a similar aim:

"Given this approach, focused around the collaborative transfer and adoption of sustainable activities, it is suggested Sub-Spokes be renamed 'HE STEM Practice Transfer Adopters and Practice Transfer Partnerships' as defined below:

- **Practice Transfer Adopters: Individual HEIs who wish to adopt and embed activities that have been developed by and within the Programme into their own practice.**

- **Practice Transfer Partnerships: A group of HEIs (or other appropriate organisations) where there exists proven good practice in a particular area relevant to the Programme's strategy, and that wish to package it and enable its transfer more widely to partner HEIs through collaborative working for the benefit of the HE sector."**

Executive Committee Paper, (March 2011)

33. Spokes were initially allocated a somewhat modest level of funds for activity (approximately £55k per spoke per year) with a view to establishing regional networks and collaborations that could then draw down larger levels of funding for more substantial activities. However, due to delays in the Programme becoming operational, and in particular in relation to recruiting the necessary complement of staff, a level of underspend quickly accrued across all partners.

34. In late 2009, the Funding Councils generously agreed that this accrued underspend could be utilised for activities that were in furtherance of the aim and objectives of the Programme, and this resulted in further funds being made available by the Programme for activities across the higher education STEM sector. As will be discussed further in Section 10, but by way of a comparison, the March 2009 proposal allocated 51.3% of the Programme's total budget to sector wide activity; comparing activity to total actual spend upon completion of the Programme, this had increased to 63.1%. In particular, the delays in recruiting staff, which were all scheduled to commence on the 1 August 2009 within the proposal, resulted in a reduction of approximately £2million to overall staffing costs.

35. Given the potential for underspend to quickly accrue, the Programme was asked by the Funding Councils in early 2010 to revise its financial reporting from six-monthly to quarterly in order that this could be carefully monitored. Monitoring took place through the submission of quarterly financial statements to the Programme's Executive Group, and via the Assurance Team at HEFCE.

Development of a Programme-wide Strategy

36. The March 2009 proposal identified the need for the creation of a strategy for the Programme's workforce development and lifelong learning activities in order to provide a framework for their successful delivery. The proposal document outlined undertaking a scoping activity to inform the strategy, however, this was cancelled as a National Strategic Skills Audit was due to be published by the UK Commission for Employment and Skills at the request of government in March 2010. In Spring 2010, with an increasing number of staff appointed, the Programme established an overarching strategy[7] for all three of its activity strands, building upon the principles and approaches defined within the proposal; this strategy was formally agreed by the Programme's Executive Committee in October 2010.

[7] http://www.hestem.ac.uk/sites/default/files/national_he_stem_programme_strategy.pdf

37. The strategy contextualised the approach taken to delivering the aim and objectives of the Programme which was through localised activities that aligned with a global strategy framework. The three-year delivery timescale, particularly given the requirement for the Programme to change university curricula and practices in a sustainable manner, meant that a series of activities and interventions needed to be quickly established if outcomes were to be realised by the end of the Programme. Enabling practice change within the HE sector at levels beyond that of an individual or single module, for example at course, departmental, faculty or institutional levels is recognised to

be a longer-term process and the full success of the Programme will not be evident during its HEFCE and HEFCW funded lifetime.

38. The strategy was designed to enable the Programme to work with HEIs who have identified priorities that align with its objectives rather than 'forcing' change upon the sector. It was felt that if an activity aligns with a wider priority or need (for example departmental or institutional), it has a higher likelihood of being sustainable in the longer-term. At the same time, the Programme did not wish activities to take place in isolation, and so a key feature of the work of Partners was bringing together those who wished to realise similar priorities, or indeed those with expertise in areas where others might wish to benefit.

39. A clear outcome from a localised approach is that a suite of activities were developed across the three strands of the Programme. Such variety has been a key feature of the Programme; in addition to ensuring the Programme meets a local need, it contributed towards enriching the practices of the sector as a whole. Members of the HE STEM sector were then far more likely to find an activity or resource with which they wished to engage, build upon, or utilise within a differing or more applied context.

Governance and Management

40. With multiple Partners and a significant number of activities to be established within a three-year timeframe, the Programme needed to have a clear governance structure: not only to ensure appropriate accountability but also to ensure coherence of activity and minimise the potential for internal duplication of effort. The March 2009 proposal outlined a tiered governance structure to reflect the different levels at which the Programme's activities would be delivered. The governance structure included: an Executive Committee, with responsibility for ensuring fulfilment of the obligations within the March 2009 proposal to the Funding Councils; a Programme Board, responsible to the Executive Committee for the operational aspects of the Programme; an Advisory Committee to help the Programme develop and maintain a high profile in the STEM community; and, Spoke Steering Groups to engage regional stakeholders in the delivery of the Programme. Professional Body Partners were felt to already have appropriate mechanisms for supporting engagement with their activities, for example Education Committees, and so no further groupings were proposed.

41. In April 2010, at the request of the Funding Councils, the Programme's Executive Committee discussed an expansion of its membership to ensure greater strategic input and high-level buy-in to the activities of the Programme by all Partners. This expansion was agreed, and was implemented for the June 2010 meeting. A proposal was also included for the establishment of a 'Governance Board' consisting of representatives from both the Funding Councils and the University of Birmingham to oversee progress towards fulfilment of the contract; strategic representation of the

Funding Councils was already in place through their membership of both the Executive Committee and Programme Board, and so the Governance Board was not progressed.

42. At the first meeting of the Programme's Executive Committee in January 2010, a framework was agreed for the use and allocation of financial resources by the Programme and its partners. The framework identified criteria relating to the use of funds for activity, and gave each Partner responsibility for the use of their allocated funds, including any underspend that had accrued; this allowed Partners to make additional staffing appointments to enable increased delivery. The framework also outlined the process for the allocation of additional funding streams, including the process of peer review through the committee structures of the Programme.

43. One remit for the Programme Board was to provide an opportunity for the coordination of activities between all Programme Partners, and as such to bring a level of coherence to the work of the Programme. Recognising, however, that membership of the Programme Board would be at 'director level', it was felt important that the Officers of the Programme had opportunity to discuss and share their work with each other to ensure complementarity and collaboration. The March 2009 proposal therefore proposed the creation of seven Special Interest Groups (SIGs) in the following areas: (outreach, enrichment and enhancement; thematic widening participation; student support; careers; the undergraduate curriculum; workforce development; and lifelong learning). Discussions between Spoke Directors in early 2010 highlighted the degree of overlap between each of these areas, and so the decision was taken that they should be 'clustered', with widening participation as an underpinning theme for each. The Universities of Bradford and Manchester Metropolitan oversaw the 'Careers, Workforce Development, and Lifelong Learning' SIG, Southampton and Swansea the 'Outreach, Enhancement, Enrichment, and Widening participation[8]' SIG, and Birmingham and Bath the 'Student Support and HE Curriculum' SIG.

Delivery Timescale

44. Within its March 2009 proposal, the Programme proposed a phased approach to its activities with direct delivery commencing on the 1 August 2009, and concluding on the 31 July 2012. The focus of the initial activities was to be firstly upon the packaging and then the subsequent transfer and embedding of the developed pilot project practices with the higher education STEM sector by the Professional Bodies and supported by the Spokes. While some pilot project activities were available for immediate roll-out, others required a period of further development and packaging prior to transfer and embedding within the higher education sector.

45. Such an approach, however, assumed Professional Body staff would be fully in post on the 1 August and a complement of staff available within the Spokes. Despite HEFCE providing continuation funding until July 2009 for three of the four pilot projects[9], many pilot project staff had already secured alternative roles before formal confirmation of Programme funding was received in June 2009. Additionally Spoke staff had not been recruited at this time, indeed some staff did not commence until summer 2010, and indeed not all Spokes had been formally recruited to the Programme.

46. A consequence was that despite the best efforts of all involved, key appointments were not made until some months after the Programme had formally started. While there was significant activity in establishing the Programme infrastructure, in reality the Programme did not become operational and engaged in the delivery of activity until the 1 February 2010; this resulted in a six-month knock-on delay to subsequent Programme milestones and timeframes. Overall, the first year of operation of the Programme focused upon establishing the delivery mechanisms

[8]Latterly renamed the Public Engagement and Widening Participation SIG.

[9]More Maths grads had been funded until January 2010 due to initial start-up delays.

and frameworks for its work, raising awareness of its existence, and beginning to embed its activities within the HE sector. The second year focused upon embedding and supporting the delivery of activity, particularly in relation to higher level skills, and the final year upon supporting projects to reach a successful conclusion, disseminating learning, and transferring and embedding developed effective practices more widely.

47. At the end of the Programme's second year of operation, a requirement of the Funding Council contract was that a review of potential for longer-term sustainability of each of the Programme's activities be undertaken. Internal and external sustainability reviews were undertaken in September 2010; the internal review identified six priorities for Programme activity in its final year of operation (Box 2.5).

1. **Synthesis of learning:** Capturing learning from across all activities and projects to ensure the collective benefit that has been gained can be utilised by the sector within the future to inform its activities and approaches.
2. **Evaluation:** Ensuring all projects are supported with their evaluations to help gather learning and capture examples of impact and success. Implementing a revised external evaluation to support the independent identification and capture of evidence of impact.
3. **Dissemination:** To ensure dissemination of the learning that has been gained, and that it is available in a format for use by the HE STEM sector in the future;
4. **Networking:** Over the final year, bringing together those undertaking related activities and projects to build longer term networks and communities of practice.
5. **Transfer of effective practice:** Enabling good practices developed by the Programme to be transferred more widely core component of this is the 'Adopter Scheme' which will enable evidence informed HE STEM activities and approaches to be implemented elsewhere.
6. **Sustainability:** Providing support, advice, guidance and expertise to existing projects to enable their sustainability within their HEIs. In addition, ensuring Programme working and approaches provide a legacy at regional and national levels, and within disciplinary communities.

Box 2.5: Priorities for Programme Activity in Year 3, Internal Sustainability Review (2010)

48. The internal sustainability review was used to inform the development of a final year Business Plan for the Programme, which not only established common specific activities to be undertaken by all Programme Partners, but also identified areas where funding might be reallocated to bring added benefits in fulfilment of the Programme's aim and objectives. Such an approach involved identifying particularly successful practices and activities, and providing additional funding to the appropriate Programme Partners in order that they might be extended more widely across the higher education sector.

49. A consequence of the Business Plan was that the Programme's overall budget was revised in conjunction with the Funding Councils from £21million to £20,612,150. This variance included the transfer of funding associated with the external evaluation of the Programme which would now be overseen by HEFCE, on behalf of both Funding Councils, rather than the Programme itself.

Evaluation and Measures of Success

50. With the Programme's aim and objectives being deliberately ambitious, a particular challenge was always going to be measuring progress towards them, particularly in a crowded STEM landscape where it is difficult to attribute causal effects to any one factor or initiative. While the Programme did seek to establish within its March 2009 Proposal outcomes for a successful Programme (Box 2.6), and a series of performance indicators that might indicate success, only two of these outcomes (1 and 2 in Box 2.5) might reasonably be regarded as quantitative, and even then a measurable increase would be impossible to attribute directly to the work of the Programme.

1. An increase in the number of young people within the STEM disciplines in HE including those from traditionally under-represented groups;
2. An increase in the number of adult learners within the STEM disciplines who, in particular, engage with part-time provision;
3. An increase in the number of learning opportunities within the STEM disciplines for those who wish to engage in study on a flexible or part-time basis;
4. A greater role for employers in shaping the STEM provision offered by HEIs, particularly in relation to the development of their workforce;
5. STEM programmes within HEIs that provide opportunities for undergraduate students to engage with those in the school and employment sectors, and provide increased opportunities for wider skills development;
6. Increased and sustained engagement between regional HEIs leading to a collaborative approach towards increasing and widening participation within the STEM disciplines;
7. The establishment of strong and sustained regional links between schools, colleges, FE, HEIs and employers with a streamlined and targeted approach to increasing and widening participation in the STEM disciplines;
8. Increased awareness of those within HEIs of the work of others in relation to higher-level skills and widening participation built around an effective and efficient approach for the sharing of effective practice in these areas.
9. Increased ownership by those within the HE sector of activities to increase and widen participation within the STEM disciplines including the successful integration of the activities of the four existing HEFCE funded Pilot Projects and the activities of others;
10. The activities and resources of the HEFCE Pilot Projects are embedded within the HE sector and the work of other national initiatives and organisations.

And a long-lasting outcome from the Programme will be:

11. The development of a national model for engagement and delivery that is self-sustaining, self-propagating and firmly embedded within the core practice of HEIs.

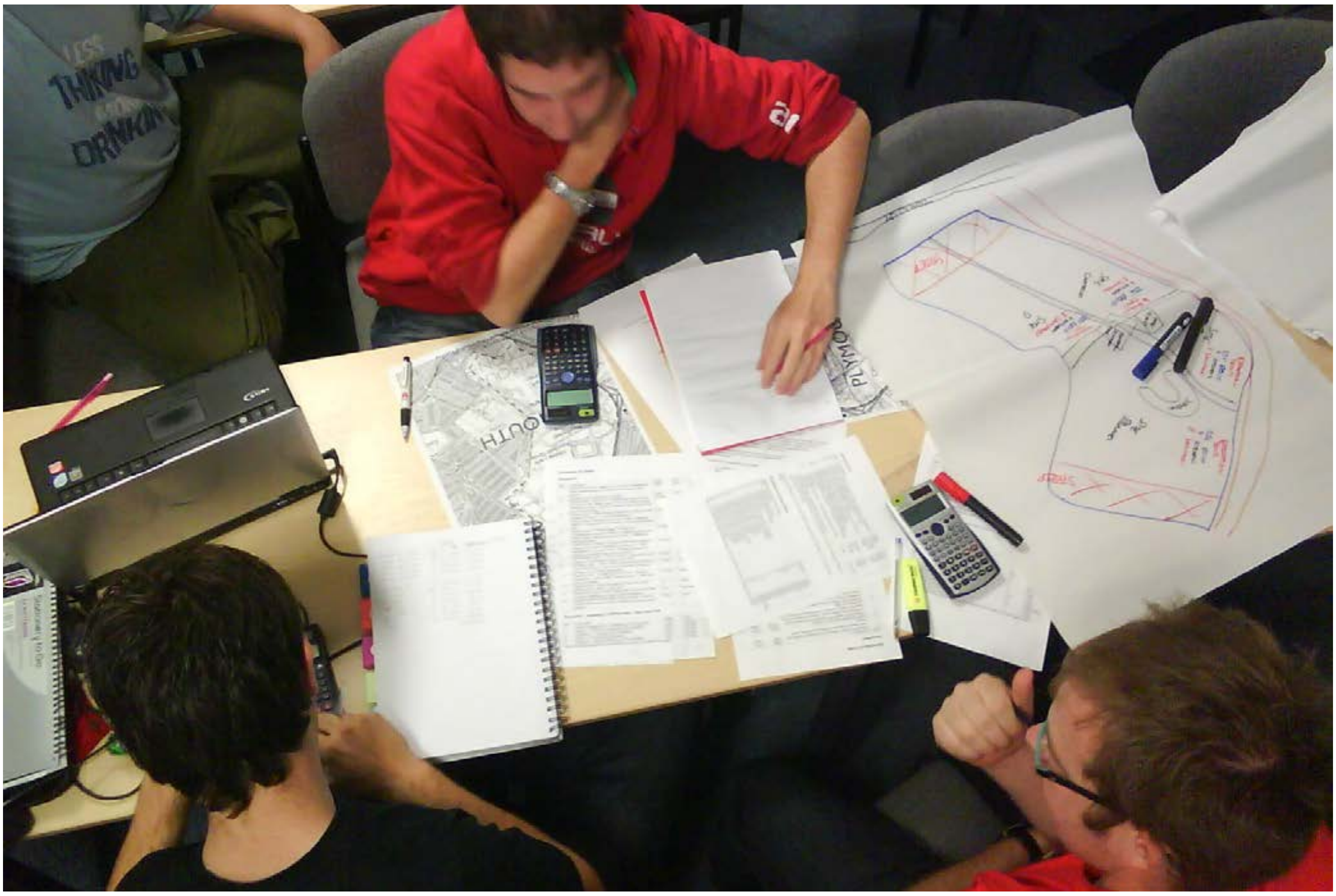
Box 2.6: Outcomes of a Successful Programme, Proposal for Funding (2009)

51. The nature and focus of the Programme was upon embedding sustainable practice change within the HE STEM sector, and as such indicators of success were more likely to be qualitative in nature rather than quantitative. A condition of funding within the June 2009 grant letter from HECE was the **"delivery of a comprehensive evaluation strategy"** and the **"development**

of more specific measurable outcomes (KPIs)", and so the Programme sought to appoint an external evaluation team who would assist with the development of a KPI framework, and provide a level of formative external scrutiny to not only provide oversight of the level of progress towards the Programme's aims and objectives, but provide feedback to inform and influence the Programme's future activities.

52. Given the scale of the Programme and the level of funding required for a comprehensive external evaluation, a tendering process was required in line with European Union regulations. An external evaluation agency was appointed in June 2010 and began work developing firstly the evaluation framework and then undertaking a level of initial (baseline) data collection. Unfortunately, the evaluation team filed for voluntary insolvency at Easter 2011, and while they contributed an external sustainability review in September 2011, the overall outputs received were limited in nature. In December 2011, recognising the changed nature of the evaluation from formative to summative due to the remaining timescale of the Programme, HEFCE sought to appoint a new external evaluation team, CFE, who commenced their work in March 2012.

53. During the development of the first evaluation specification in June 2010, the programme identified six areas, and associated indicators of success, upon which the evaluation should focus. The six areas were: partnerships; sustainability; transferability; institutional impact; employer engagement; and, widening participation. These six areas, coupled with the outcomes defined in Box 2.5 provide the basis by which this report will be structured.



The Changing Higher Education landscape

54. It would be wrong to conclude this section without considering how the educational, political and financial landscape of the United Kingdom has changed over the three years in which the Programme operated, as each has provided challenges the Programme has needed to overcome.

55. When the Programme was developed in late 2008, its remit was created in response to priorities defined by the previous government, and in particular its higher level skills strategy:

> **"It sets out clear aims –**
>
> **To produce more, and more employable, graduates**
>
> **to raise the skills, and capacity, for innovation and enterprise, of those already in the workforce" Higher Education at Work - High Skills: High Value (DIUS, 2008)**

56. This strategy underpinned the aims, objectives and delivery model of the Programme, but when a coalition government was formed in May 2010, it signalled the start of major policy changes. An emergency budget in June 2010, in response to a changed worldwide financial climate, announced a series of austerity measures which impacted directly upon the Higher Education Sector with student number control implemented within England and a reduction in the number of additional university places for STEM in 2010/2011 from 20,000 to 10,000; in Wales, HEFCW made arrangements to cap students numbers at 2008/2009 levels from 2011/2012.

57. While STEM remained a priority for the Coalition Government, its focus appeared somewhat different. The Coalition Government continued to invest, quite rightly, in existing successful STEM initiatives, such as STEMNET and Science and Engineering Week, but the emphasis upon priorities for activity within England appeared very much upon reform of the education system at school level, and the work of higher education to widen access and participation, rather than upon workforce upskilling in particular. In Wales the situation was perhaps slightly different; a letter from the Welsh Assembly Minister for Children, Education & Lifelong Learning called upon HEFCW to continue to work to support the **'industries and technologies of tomorrow'** and in **'encouraging the HE sector to develop strategic relationships with businesses across Wales, the UK and globally'** with explicit reference to the STEM disciplines.

58. While widening participation underpinned the entire programme, the delivery level of its strand of activity focused upon enhancing the interactions of higher education institutions with schools and colleges was due to be gradually reduced as the Programme progressed. Instead, this strand of activity became increasingly important when, in October 2010, Lord Browne of Madingley published his independent review of Higher Education Funding and Student Finance within England.

59. The Browne review proposed significant changes to the way higher education is funded, with the emphasis for funding higher education being moved further from government to the student. The report indicated that universities would be able to implement a higher fee threshold, but in doing so would place a greater emphasis on universities to demonstrate their commitment to widening participation from under-represented groups, and in the scrutiny of teaching quality. A higher student fee threshold was subsequently accepted by Parliament, and a significant focus for sector-wide discussion to date has focused upon the need for universities to detail within their annual access agreements a commitment to widening participation.

60. Following the decision in England to increase tuition fees the Welsh Assembly Government announced Welsh institutions would also be allowed to charge higher fees, albeit with a different lower fee threshold to England. Fee Plans in Wales focus on two areas: equality of access and promotion of higher education in Wales; universities must explicitly detail their contribution to each.

61. What received less attention across the sector is that the Browne report also proposed support packages for part-time students for tuition and living that were not accessible in the previous funding. This very much aligned with the Programme's objectives, and with much work in this area already underway, it was important that this continued to not only provide learning opportunities for those within the current workforce, but also essential learning to help the sector better understand and implement flexible delivery mechanisms.

62. The changed financial climate itself had a number of implications for the Programme. For its workforce development activities, some employers who had made commitments regarding the number of students who were to participate in the developed provision, reduced their numbers downwards. Additionally, funding sources for higher education activity, which had previously been plentiful, became increasingly scarce, and the Programme appeared to be seen as one of the few remaining sources.

63. Throughout the three-year lifetime of the Programme, there existed considerable uncertainty in terms of continued funding for existing organisations with which the Programme indicated a clear intent to work at its outset. The Aimhigher Programme formally closed on the 31 July 2011, although members of the higher education sector have continued to work successfully with the legacy organisations that resulted from its work. In November 2010, the Higher Education Academy announced a revised delivery structure that would see the loss of the Subject Centres from August 2011. While the Higher Education Academy developed a subsequent disciplinary presence, this was in its very early stages over the final year of the Programme.

64. The loss of the Subject Centres was a significant blow as the Programme had not only engaged two Subject Centres to deliver significant strands of activity, but the Subject Centres were at the heart of its dissemination strategy given their strong, and established disciplinary networks. The Universities (Birmingham and Loughborough) who hosted the Subject Centres ensured the activities being undertaken on behalf of the Programme were successfully completed, but the situation in relation to activities and events became complex, particularly as a number of projects who had committed to running dissemination events through their respective Subject Centres within their proposals planned and delivered their own individual events. To help better co-ordinate the array of dissemination activities, a full-time Dissemination Officer was appointed from 1 August 2011 to work across the Programme.

Section 3:
Partner Perspectives

Introduction

1. The National HE STEM Programme delivered its activities through a 'Hub and Spoke' model: six universities working in conjunction with four Professional Bodies to undertake a range of activities within the higher education sector across England and Wales. While each Professional Body partner had identified at the Programme's outset pilot project activities that it would build upon and seek to transfer and embed more widely, the activities of the Spokes were more broadly defined and were to be developed as the Programme progressed to meet the needs of their constituent regional universities.

2. This section provides a brief overview of each Partner's approach to delivery, the priorities they sought to address, and any key challenges they faced in undertaking their work. The original intention for this section was to include a commentary from each partner in full, however for consistency individual partner submissions have been edited and their comments and findings are summarised here. In particular, key findings and recommendations from each partner have been used to inform the overall Programme's recommendations and conclusions within Section 11. Each individual partner submission is available to the Funding Councils upon request.

Partner Perspectives

London and South East Spoke

3. While the Programme's regional Spoke boundaries were redrawn (Figure 2.1) following submission of the proposal to the Funding Councils, the London and South East region of the Programme was by the largest with some 33 higher education institutions with STEM disciplines represented by the Programme. To support the activities of the Spoke a Regional Steering Group was established consisting of senior managers with STEM backgrounds from 15 higher education institutions across the region to offer advice and identify regional needs.

4. The Steering Group recommended a managed approach to funding and dissemination, and identified seven regional priorities:

- Need for a clear regional identify for the Programme with aims and benefits made evident and defined funding opportunities for regional projects;

- Improved retention and progression through improved study skills development, particularly for widening participation students;
- Effective harvesting of employer contributions to undergraduate experience, including guest lectures, provision of project work and work placements;
- Proportions of women increased in physics and engineering;
- Proportions of Afro-Caribbean students increased in all STEM areas;
- Improved quality of outreach and engagement with schools;
- Better understanding of UK education system by non UK academics in the region.

5. The delivery of these priorities was overseen by a team based at the University of Southampton. A 0.4FTE Regional Director was recruited in Summer 2010 and was joined by an Outreach and Widening Participation Officer at the same time; a Higher Level Skills Officer was appointed in late 2010. Delivery of the Programme's activities across the region were supported by individual universities, while contributions on a more sub-regional scale was provided by South East Physics Network (SEPnet), Science Learning Centres, UK Resource Centre for Women in Science Engineering and Technology (UKRC), STEMNET and the professional bodies.

6. The London & South East Regional Steering Group advised against offering open funding calls due to the large number of departments, and managed call approaches were adopted which additionally utilised underspends that had accrued while the regional team was being appointed. In establishing these activities Spoke Officers sought to encourage individuals from different higher education institutions to work together, but found limited success; the Spoke reported that feedback from universities indicated that **"collaboration was seen as against their best interests due to the need to compete for students and for funding"**. The Spoke also reported that the Programme's requirement to make materials freely available to the sector also dissuaded individuals from pursuing projects with the Programme.

7. The Spoke highlighted issues of compatibility between regional priorities and those of the Programme: **"There is evidence that the high numbers of graduates already employed in the region and the high number of SMEs meant that few employers were interested in engaging with L&SE HEIs to develop bespoke workforce up-skilling provision, unlike in areas where there are more larger employers: an incompatibility between regional needs and the criteria for funding. As employers require their STEM workforce to be upskilled in areas of leadership and management, rather than STEM-specific skills, an opportunity to apply for funding for this would have elicited more interest from both employers and HEIs across the L&SE region."**

8. Further, the Spoke reported changes within its regional higher education institutions over the course of the programme: **"a significant number of L&SE HEIs experienced considerable**

restructuring, staff turnover/redundancy and curriculum redevelopments which impacted on project activity and engagement with events."

9. Overall, of the 33 higher education institutions in the region with undergraduate STEM provision, 17 engaged directly with spoke projects and a further 8 engaged with the wider Programme through other national funding calls, project work or partnerships.

Midlands and East Anglia Spoke

10. In redrawing the Programme's boundaries and reducing the region scheduled to be covered by the (now) London & South East Spoke, the Midlands region was expanded to include East Anglia. This meant the Midlands and East Anglia region of the Programme had 23 higher education institutions with STEM provision and five further education colleges with higher education provision. A regional Steering Group was formed with representatives from higher education institutions, STEMNET and Professional Body Partners to help develop and inform the regional strategy.

11. To initiate its activities, the Spoke held a scoping workshop in January 2010 to which all higher education institutions in the region and the Professional Bodies were invited. The meeting helped establish networks within the region, and ongoing visits to higher education institutions helped identify colleagues with interests and expertise that aligned with the Programme's objectives and allowed effective practices to be identified.

12. The West Midlands has one of the highest proportions of part-time students and an above average proportion of mature student. Like the West Midlands, the East Midlands area has below average levels of qualifications and one of the lowest proportions of 16 year olds remaining in education. Despite the above average employment rate in the East Midlands, the majority of employed residents are in occupations requiring few or no qualifications. A high proportion of the activities explored by the Spoke were skills related, reflecting the region's priority to train and retain its graduates.

13. In total the Spoke engaged with 20 higher education institutions through briefings and information sessions, and collaborated on a deeper level with 17 of these by initiating and supporting activities.

North East Spoke

14. The North East Spoke of the Programme encompassed the former Regional Development Agency regions of Yorkshire and the Humber and the North East. The economic challenges facing Yorkshire and Humber include training, re-training and redeployment for those affected by the reduction in public sector employment and the continuing decline in manufacturing employment; key challenges are promoting graduate potential to businesses, encouraging degrees which reflect demand and to make graduates more work ready. In the North East there is a need to upskill the existing workforce to meet employer needs both now and in the future, with a particular emphasis on narrowing the gap in possession of level 4 qualifications between the North East and the rest of the UK, and raise the aspirations and take up of higher level qualifications by its school leavers.

15. The North East Spoke region contains 14 higher education institutions as well as a number of colleges of higher education; the Spoke succeeded in working effectively with all higher education institutions offering STEM learning, and with a number of the further education colleges in the region. Funded projects have encouraged higher education institutions to collaborate across and within the region for specific disciplines but also for cross-disciplinary working. Schools and colleges have participated with widening participation activities and several projects have specifically worked with community groups to inspire and influence families in their understanding

and experience of STEM with the aim to raise aspirations. Where relevant other stakeholders have been involved, such as the professional bodies but also organisations such as the Frank Buttle Trust (Buttle UK) providing support on the 'looked after children and young people' project.

16. The Spoke reported that successful engagement and delivery had been due to a number of factors including: building its activities around a programme identified by its Regional Steering Group which was formed following an open call for expressions of interest to join; the management practices of a small central Spoke team, the governance of the North East programme through effective communication channels and extensive collaboration with HEIs, schools, colleges and associated stakeholders; the priority selection and efficient funding allocation to projects in order to meet the objectives set in the regionally endorsed operational plan; and, making the regional programme more inclusive by holding workshops and seminars in a central location (often the National STEM Centre in York) rather than the Spoke University.

17. The Spoke reported evidence that participants have now embedded activities, curriculum and methodologies from other higher education institutions into their own practice, and this is evidenced by the activity of the region in the Practice Transfer Adoption scheme. It further noted that projects came together to share information and progress in a collaborative way and that there was evidence a commitment to put aside institutional competitiveness to share good practice.

North West Spoke

18. The North West Spoke region consisted of 14 higher education institutions of which all but two offered STEM provision aligning with the disciplines represented by the Programme. The levels of STEM degree course provision has remained reasonably stable over the period 2006 – 2012, and with the North West being the largest manufacturing region in the UK, many STEM related industries are based around the Mersey River and Manchester areas; many of the highest profile employers are STEM related.

19. The North West Regional Steering Group contained representatives from 10 North West higher education institutions, a Sector Skills Council, the North West Universities Association, the North West Development Agency, and the North West Science Learning Centre. The Steering Group identified a series of priorities for activity:

- Student Access to higher education STEM Subjects;
- Promotion of STEM Careers at Critical Decision Points;
- School to University Transition and Curriculum Enrichment;
- HEI Involvement in Schools and Colleges outreach;
- Coordination with Employers.

20. The Spoke identified a method of working collaboratively with higher education partners, supported by discipline specific networking, that enabled it to identify and support relevant projects within the region. For example, in developing its Regional Action Plan, a workshop involving representatives from all higher education institutions and key regional organisations was held; this facilitated the coordination of proposals involving multiple universities that addressed all Regional Action Plan priorities. The overall success of this collaborative approach to project identification and support is demonstrated by the 100% completion rate, wide spread engagement (all bar one of the North West projects involved more than one higher education institution) and the utilisation of all the resources available to the spoke. Twelve of the fourteen North West Universities participated in

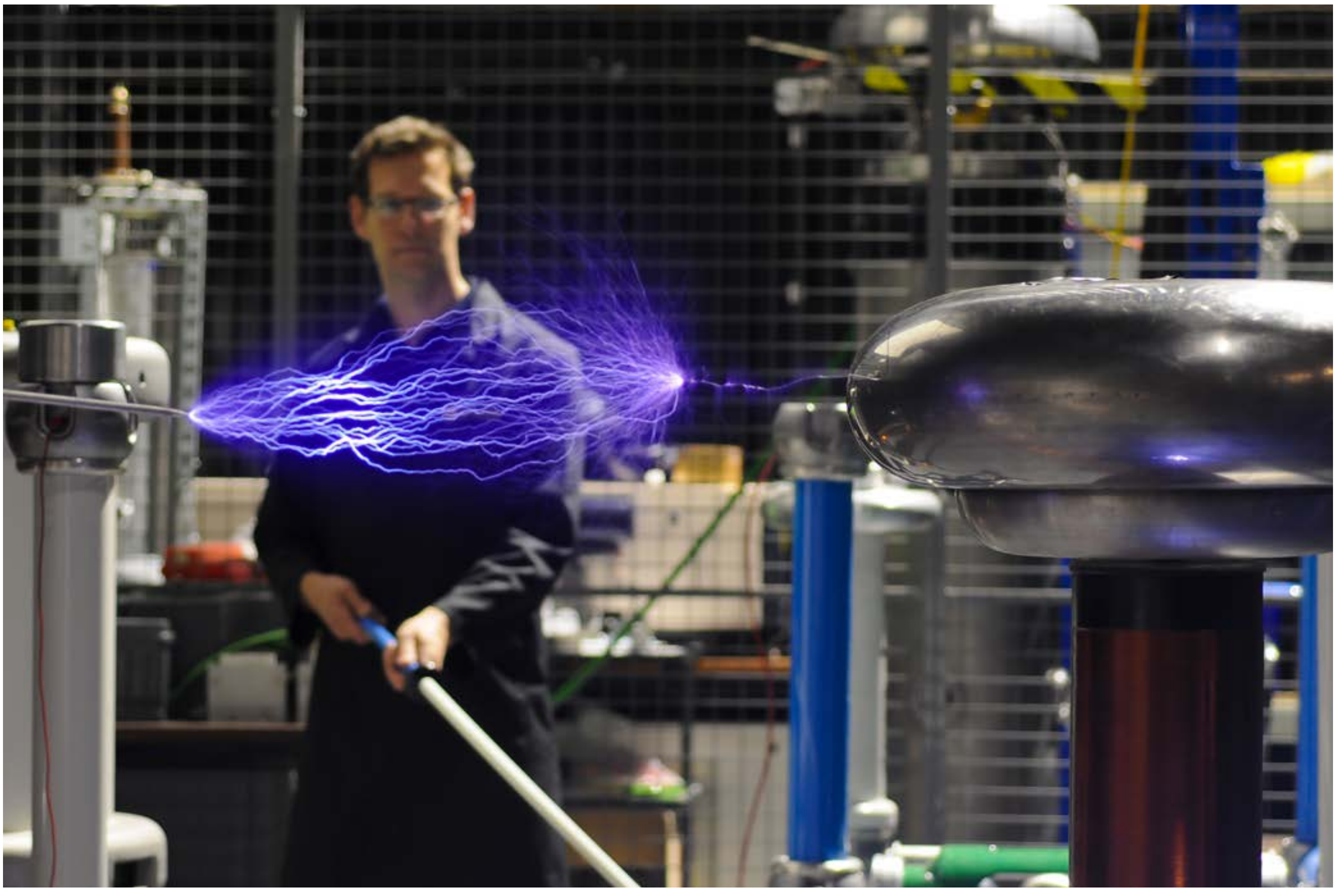
Programme related activities, either directly or indirectly, and 10 of these led on the delivery of one or more specific interventions.

21. The Spoke reported that as a consequence of the Programme, regional higher education institutions are now much more attuned to the existence and value of repositories of information regarding STEM skills gaps in the labour market and there is a heightened awareness amongst their careers services of the factors affecting career pathways for STEM students. In particular, all higher education institutions with STEM provision are actively engaged with a new regional online portal for employers who wish to access STEM relevant expertise.

South West Spoke

22. The South West Spoke was geographically the largest region of England, and has great contrasts in economic performance largely due to regional variations in rurality, access to major transport routes, together with levels of education, training, innovation and skills. The South West region contains 13 higher education institutions, of which four are higher education colleges; of these, six have significant STEM provision and each was represented on the Regional Steering Group and participated in a range of projects. In addition, the region also contains 28 further education colleges.

23. The South West Spoke sought to initiate collaborative working between its regional higher education institutions and to develop links with other relevant stakeholders, for example the National Co-ordinating Centre for Public Engagement (NCCPE) is located in the region at the University of Bristol and has been a collaborative partner within public engagement projects. In total, over 30 organisations external to the higher and further education sectors were involved as collaborative project partners, including examples from the commercial world, the public sector and the third sector.



24. An initial regional consultation meeting was held at the University of Bath in December 2009 to initiate the formation of regional discipline networks and identify regional priorities. This, coupled with widespread consultation with staff at higher education institutions across the region led to the identification of themes for the managed call projects focused upon widening participation and student support. The successful proposals for the higher level skills projects were deliberately designed to be larger scale and multi-partner so as to create synergy through collaboration, and were also developed in a collaborative manner with stakeholders; a large scale regional meeting was held to consult on themes and encourage participation.

25. The South West launched its own Programme website[1] at the end of January 2011, and included a project collaboration tool to facilitate multi-institutional project working. This provided a private space for project team members to store shared files and enabled them to update their own project's external web pages. This was transformed into an archive site on the 1 June 2012 with a very strong focus on project outputs including fifty separate CPD resources across the strands of widening participation, HE curriculum and workforce development.

26. South West Spoke projects highlighted the valuable role that students can play as change agents in enhancing learning, teaching, assessment and support activities in the region as well as helping to raise the profile of important issues relating to STEM curricula at a strategic level in universities and the value of outreach and public engagement. The Spoke also highlighted the significant role that Spoke Officers played in brokering projects, monitoring their progress, and assisting with the delivery of their activities; this was acknowledged in feedback from project leads.

Wales Spoke

27. During the duration of the National HE STEM Programme Wales had 11 higher education institutions; three in mid and north Wales and the remainder in south Wales with the exception of the Open University which works across all of Wales. With the exception of one university, all had undergraduate provision in one or more of the disciplines represented by the Programme. The work of the Programme took place in a time of significant strategic and structural change in Wales[2], and the Spoke reported that this, to some degree, affected the ability of higher education institutions to engage with the Programme and collaborate.

28. Slightly fewer workers in Wales than the UK as a whole have qualifications at level 4 and above and more have no formal qualifications at all. There are marked regional differences in the availability of jobs in Wales in terms of sector, occupation and concentration with the south east contributing close to 50% of all jobs. Wales also has a net outflow of workers. Activities to support the development of the workforce were therefore a priority for the Spoke.

29. Following an initial launch conference at Swansea University in 2010 to outline the Programme to stakeholders, a series of meetings were held across Wales with representatives from all STEM departments in June and July 2010. From these meetings a list of priorities was developed which reflected the different strategic interests of the higher education institutions and which formed the basis of the Spoke's operational plan. Higher education views on engaging with the Programme differed, and so 44 small projects (less than £20,000) were established to support a range of different activities. Few projects involved cross-institutional collaboration, and the Spoke reported **"this was due to the short timescales available for developing projects."**

30. Regional Steering Group members were recruited, and in addition, heads of department were asked to nominate 'champions' who would facilitate the engagement of their institution; the majority of departments did so and engagement within these institutions was found to be much easier than

[1] http://www.hestem-sw.org.uk

[2] Higher education in Wales is currently undergoing reconfiguration with a number of universities in the process of merging.

with those who did not. To maintain communication with the wider higher education sector two 'Engage' conferences were held to showcase the work of the Programme.

31. With the conclusion of the Programme, the Spoke reported that on the part of Welsh Universities **"there is interest in and willingness to build upon the successes of the Spoke's work. Currently the possibility of working through Higher Education Wales is being explored with a view to establishing a working group to support future collaborative engagement."**

Royal Society of Chemistry

32. Data shows that the number of chemistry A-level entries and number of applicants for university chemistry courses has fluctuated in recent years. The RSC's pilot project, Chemistry for our Future has in part contributed to the increase uptake of chemistry A-level and degree courses and the work of the RSC within the National HE STEM Programme was instigated to build upon this.

33. The RSC has noted critical points in the education 'pipeline' as barriers to progression into, and within, undergraduate chemical courses and on to employment in the chemical sector. At each side of the school-university interface issues exist with: knowledge of the curriculum amongst school teachers and higher education staff; pedagogic differences in course delivery create a challenging environment for new undergraduates; and, skills and knowledge gaps are frequently cited as a barrier to progression at undergraduate level.

34. At the university-employment interface: employers perceive graduates are unprepared and lacking essential skills; students are observed to have little experience of the relevance of a concept or a topic to a real work application; and, in contrast to secondary school, much university chemistry teaching is didactic in nature. Through the Programme, the RSC's activity aimed to:

- Generate interest in chemistry at secondary level;
- Improve retention rates amongst those entering chemistry courses in higher education;
- Improve the quality and relevance of the learning experience of higher education students to make the courses more attractive to students, and produce students that are more attractive to employers.

35. To deliver on these aims, the RSC identified four major themes of activity building upon the Chemistry for our Future pilot:

- Spectroscopy in a Suitcase: An opportunity for higher education institutions to engage with schools in delivering activities that are beyond their means but which add value to the teaching;
- Context and Problem Based Learning: Improve the undergraduate teaching and learning experience through a means of delivery that is recognised to increase student engagement with a subject and aid the development of higher level skills;
- Employer Engagement: The implementation of new approaches as this was an area where there was no clear success for the Chemistry for our Future Pilot project. These approaches included the development of business skills courses, reflective portfolios, advisory boards and placements;
- School Teacher Fellows: The secondment of teachers to work within higher education institutions for a year working on a programme of objectives aimed at improving retention, enhancing teaching and learning, and developing relationships with schools.

Institute of Mathematics and its Applications

36. The numbers studying Mathematics A-level, Further Mathematics A-level and Mathematical Sciences degrees has risen sharply in recent years. There has also been an increase in the number of higher education institutions offering a mathematical sciences degrees. In terms of the employment landscape there is however a continuing shortage of people who are suitably qualified mathematically; for example, there remains a shortage of mathematics teachers in UK secondary schools.

37. In July 2012, the House of Lords issued a report on Higher Education in STEM subjects which identified the surprisingly large percentage of students entering STEM disciplines without having taken A-level mathematics. The underpinning nature of mathematics to engineering and physics is long established and well known. What is less well known is the rapidly increasing importance of mathematics to chemistry and particularly the biological sciences. This so called 'Mathematics Problem' was first documented in the mid-1990s and despite various Government initiatives it still remains a major concern.

38. The maths strand of the Programme aimed to:

- Build on the More Maths Grads pilot by engaging employers with mathematical sciences departments and providing outreach and careers materials;
- Enable curriculum innovation in key areas identified by the higher education mathematics community (led by the Higher Education Academy Subject Centre for Mathematics, Statistics and Operational Research);
- Enable the provision of mathematics and statistics support to students in addition to that provided as part of their undergraduate course (led by **sigma**).

39. Existing networks were used to promote and disseminate the activities, including those developed during More Maths Grads and the Heads of Departments of Mathematical Sciences (HoDoMS). Over 95% of higher education departments which offer a mathematical sciences degree in England and Wales were involved in mathematics strand activities through the National HE STEM Programme.

The Institute of Physics

40. The years leading up to the turn of the century were very difficult for physics. Although the number of university entrants had not fallen dramatically, the subject had not benefited from the large increase in participation generally and, as the more popular departments took more students to improve their financial viability, there was a series of departmental closures and more than a third of the physics provision disappeared. Indeed, the vast majority of both physics courses and students became concentrated in the most prestigious universities.

41. In parallel with the departmental closures, the numbers of students taking A-level Physics fell from a peak of above 50,000 in the mid-eighties to below well below 30,000 twenty years later. The

number of specialist physics teachers recruited fell to an annual average between 300 and 400, when a break-even figure of 700+ was required to compensate for the teachers leaving and retiring from the profession. One serious consequence of the shortage of specialist teachers which, in England, ran to about 40%, was that much of the teaching of physics up to and including key stage 4 was done by non-specialists, principally biologists.

42. There are two substantial problem areas in terms of the diversity of participation in physics. First, in moving from GCSE to A-level, the percentage of girls falls from 50% to 20%, a fall that has remained stubbornly constant despite a multitude of activities designed to persuade more girls into the subject. The second problem area is in the participation of students from the lower socio-economic groups. Physics is one of the least diverse subjects in this sense. There are a number of reasons for this situation; one is undoubtedly the concentration of the provision into the most prestigious universities, which has led to physics entrants having the highest average UCAS points of any of the STEM subjects. Another reason is that many students from the lower socio-economic groups prefer to live at home and attend a local university, usually one that has strong links to the community, exactly the type of university that closed its physics department. Finally, physics entrants are required to have A-levels in both physics and mathematics, two subjects often perceived as being amongst the most difficult. Participation in A-level physics is strongly correlated with social class and, perhaps due to the shortage of specialist teachers, schools in inner-city areas and similar environments are much less likely than average to send students to do A-level physics.

43. Physics graduates have a good reputation among employers and, two or three years after graduation, unemployment levels are very low. It is also noticeable that physicists enter a wide range of different areas of work. Some employers, however, have complained that physics graduates, while having a sound knowledge base, lack some of the wider skills that would serve them well in a business environment. Against that, physics has the highest rate of progression to postgraduate study of any STEM subject, and a PhD course is by far the most popular destination for physics graduates.

44. Given this, the areas identified as the most important in trying to encourage more students into physics and physics-related courses in universities were:

- The transition from GCSE to A-level in schools and the associated problem of the lack of specialist teachers;
- Improving links between schools and universities;
- Increasing diversity in physics;
- Altering the image of physics to make it appear more welcoming;
- Providing routes into physics and physics-related course for non-traditional students;
- Demonstrating the employability of physicists;
- Improving connections between business and physics in schools and universities.

45. These themes formed the basis for the original pilot project Stimulating Physics. When Stimulating Physics was assimilated as part of the National HE STEM Programme, the emphasis shifted away from the school-based work. However, that work proved so successful that the government took up the mantle and funded it themselves; funding has continued across the change in government and very positive results are being seen in the take up of A-level physics.

Royal Academy of Engineering

46. Three areas formed the focus of RAEng's work through the National HE STEM Programme:

- Curriculum innovation;
- Engineering for society (including widening participation and diversity);
- Education research.

47. The widening participation projects were distinct from outreach in that they were focused specifically on curriculum development or research that enabled access to higher education for diverse groups (whereas outreach is targeted at school pupils). Projects focused on Black and Minority Ethnic groups, adults, females and first generation higher education entrants.

48. Many of the education research projects are better described as specific investigations into particular aspects of practice. Three projects attempted to really research the fundamental pedagogy of engineering education and to try to understand how engineering students learn, what they find difficult and how learning can be better enabled for them.

49. RAEng also oversaw a number of larger strategic projects including the Nuclear Island project, the Engineering Gateways Workforce Development project, Support for University Technical Colleges project as well as leading the Workforce Development Practice Transfer Partnership on behalf of the Special Interest Group headed by Manchester Metropolitan and Bradford Universities.

50. Of the projects initiated through RAEng, project leaders were encouraged to engage with employers and collaborate with other universities in order to pool expertise. 52% of projects indicated that they had sought some form of engagement with employers. Only a few collaborative projects however appear to have attempted to engage new partners or networks. Both universities and employers continue to collaborate with established partners and networks and appear reluctant to explore other possibilities or develop new collaborations. In the few instances where this did happen, the collaborations were particularly successful, but inevitably required considerable investment in time and the resources of a dedicated individual.

51. Project outcomes were disseminated within home departments, within host institutions, to other institutions and to employers. A number of dissemination methods were used, including seminars, websites, staff continuing professional development and publications. Most projects relied heavily on the website dissemination and publication opportunities provided by RAEng and the National HE STEM Programme; an additional output of a book of collated case studies was produced to bring together learning from RAEng's work throughout the Programme.

Programme Hub (University of Birmingham)

52. Within the Programme's original delivery model, as outlined within its March 2009 proposal, the role of the Hub was defined to be as follows:

> **"The 'hub' HEI will contain capacity to support and enhance the activities within all 'spokes'. This will include a central team who will have responsibility for financial management, ensuring co-ordination between the activities of the 'spokes' to facilitate the sharing of effective practice and thereby reduce duplication of effort within the Programme, undertaking reporting to HEFCE, national dissemination and promotion, evaluation, and undertaking specific programmes of activity and research that cross all 'spokes'." National HE STEM Programme Proposal Document, (March 2009)**

53. The role of the Hub was broad, and as the Programme developed, it took on an increasing role in undertaking delivery of the Programme's activities within the higher education sector. While Spokes were becoming operational, the Hub launched, managed and supported the Programme's first open call projects through the Collaborative Projects initiative. In late 2010, the Hub initiated 12 large scale curriculum projects which it then continued to support over their approximately 18 month duration. Both initiatives proved to be a success as they enabled projects across all the Programme's regions and disciplines to be established, while the collaborative projects in particular demonstrated the value that can be achieved for relatively modest sums by transferring effective practices between high education institutions. The learning from this call went on to influence the Menu of Activities and the Practice Transfer Adopters initiatives.

54. The loss of the Programme's external evaluators due to voluntary insolvency during Easter 2011 posed particular challenges to the Hub. While an external sustainability review was undertaken at the end of the Programme's second year of operation as required by the Funding Councils it lacked essential detail, and as such the Hub needed to undertake the Internal Sustainability Review. Following submission of the Internal Sustainability Review, the Hub undertook the production a final year business plan which provided the opportunity to develop and extend successful practices from across the Programme; in doing so, the Hub undertook two additional projects. The first was a Regional Action Plan project at the University of Wolverhampton, and the second was overseeing a series of 'synthesis activities' to capture learning from across the Programme.

55. While the loss of the external evaluators posed significantly challenges for the Programme as a whole, it also presented an opportunity that has been one of the key features of the Programme. With a lack of external data collection, the emphasis moved to supporting projects to collect their own data and evidence of impact through evaluation and research. Through a Programme wide working group, a series of workshops, conferences and resources for project leads on evaluation and research were established; the impact of this work appears evident in the evaluations of the projects whose leads participated. The University of Birmingham has been able to continue this strand of work in conjunction with the RSC working with the Higher Education Academy.

Section 4:
Collaboration and Networking

Introduction

1. At the heart of the Programme's March 2009 proposal to the Funding Councils was a commitment that its activities within the higher education STEM sector would be developed, delivered, and disseminated in a collaborative manner. In particular, two of the Programme's objectives (Box 2.2) explicitly cited the need for a collaborative approach, and two further implied collaboration through the **'integration and strategic development of existing activities, initiatives and resources'** and the **'community-wide sharing and dissemination of good practice'**.

2. Collaboration was felt to be essential, particularly with existing STEM sector organisations, if duplication of their work with schools and colleges was to be avoided, and instead higher education specific value added. The Programme's objectives also recognised there existed a range of effective practice upon which its work might build, and as such several key delivery partners, for example the **sigma** centre for excellence in university-wide mathematics and statistics support (Loughborough and Coventry Universities), and the Higher Education Academy.

3. Subject Centres for Mathematics, Statistics and Operational Research and Engineering, were engaged at the outset of the Programme to undertake delivery of specific themes of activity. Further, the Programme's delivery approach was designed with collaboration firmly in mind; in its initial stages collaboration between the Spokes and Professional Bodies would enable the transfer and embedding of pilot project outcomes into the wider higher education STEM sector, but as the Programme developed, collaboration between partners would underpin the development, delivery and dissemination of national and regional activities.

4. Given the range of collaborative activity taking place across the Programme, in April 2012 a 'synthesis report' was commissioned to further explore the approaches implemented and to identify effective practice. This synthesis report, authored by Susanne Haselgrove, will be published through the University of Birmingham's STEM Education Centre shortly, but its findings are utilised here to discuss the range of collaborative activity in an overarching sense. As collaboration has formed a specific feature of the Programme's work across its three strands, further examples of the collaborative activities developed are highlighted within Sections 5 – 7 of this report. In particular as collaboration with employers and employer organisations was an embedded feature of the Programme's higher level skills work, this will be discussed separately within Sections 6 and 7.

"There is no doubt that the promotion of collaboration and partnership has lain at the heart of the set-up, operation and legacy of the National HE STEM Programme." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

A Spectrum of Collaborative Engagement

5. Collaboration across the Programme has taken many different forms, and as such needs to be considered in its broadest sense. The Programme's approach has not only involved enabling collaboration amongst those working within the higher education sector, either between different institutions or within individual institutions, but has also enabled the higher education sector to work more effectively with a range of existing STEM sector organisations and employers on activities of mutual benefit. A further feature of the approach is that it has sought to involve both current and future generations of learner; this includes engaging both undergraduate and postgraduate students in the design, development and delivery of activities, and the collection of data and evidence to better inform university practices when working with those in the school and college sectors.

6. While the design, development and delivery was a key feature of the Programme, equally important was the sharing of learning and effective practice. The Programme actively sought to bring together individuals with mutual interests to support the development of collaborative activity, and enable opportunities for effective dissemination to occur. Additionally, a collaborative approach, through the Practice Transfer Partnership schemes, was utilised as a means of 'active dissemination' by encouraging the wider uptake and adoption of effective practices that had been developed.

7. Collaboration within the National HE STEM Programme can be considered on the basis of a hierarchical series of levels. At the lowest level 'involvement' is characterised by individuals being invited to participate in Programme activities, events, meetings or workshops; such an approach was often non-targeted and the evidence suggests that this was the least successful as often recipients could not see the benefit to themselves of becoming involved with the proposed activity. At the intermediate level 'engagement' involved a more proactive, and personal approach by the Programme whereby partners sought to understand what was important to various stakeholders and explore how they might become engaged in its work. Such an approach meant that partners were able to align Programme objectives to those of other individuals and organisations:

"Through this approach some new collaborative working was made possible that would not have existed without the National HE STEM Programme." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

At its highest level, collaboration was based around 'partnership', and the most effective collaborative working was achieved whereby partners were able to 'plug into' existing networks or groups. In some instances these were established formal networks, for example STEMNET, but in others they were partners who had a successful track record of working together to achieve mutually beneficial goals, for example **sigma**:

"There is consistent evidence that the most successful collaborations were where partners could demonstrate that involvement with National HE STEM Programme initiatives would add value to the shared goals already established. In order to achieve this, in many cases, partner team members went through processes of engagement in order to be able to demonstrate the synergies that involvement in National HE STEM Programme activity would deliver." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

The Extent of Collaborative Activity Across the STEM Sector

8. Understanding not only the extent of collaboration within the Programme but also the factors that enabled collaboration to be successfully achieved was one of the reasons that the Haselgrove report was commissioned. It identified three factors that promoted collaboration: working with existing collaborations and partnerships that had a prior history of trust and working together for mutual benefit; the personal qualities of Programme staff and project leads and their commitment to collaborative working; and, a proactive and explicit commitment to collaborative activity embedded throughout the Programme:

"…their [Programme staff] proactive and explicit commitment to promoting collaboration ensured that this approach permeated the strategic framework for project identification and selection." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

9. Although collaboration and shared working has been a significant feature of the Programme, there were factors that mitigated against successful collaboration or made it harder to achieve. Changes, or perceived changes, in government policy were a key factor:

"A strong view was expressed that these policy changes impacted particularly on the workforce development/employer engagement strand of activity, the importance of which to universities became a much less important policy driver. For those not already working with employers there was consequently less of an imperative to do so both individually and collectively. A similar, but possibly more complex, effect was discernible in relation to the widening participation strand of activity. Whilst the Access Agreements that individual institutions are now required to have continue to make widening participation an important policy driver, the reduction in student numbers, changes in funding regimes and the disappearance of Aim Higher networks militated against collaborative approaches to supporting these activities." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

Similarly the Programme set-up and operation:

"…the National HE STEM Programme set up process had a major impact on the extent which collaboration could be delivered in that there was no time for a measured view to be taken of what delivering on the collaborative strands of the Bid required." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

10. Nevertheless, collaboration was at the heart of the Programme's March 2009 proposal, and this was further reinforced when it was defined as one of the six principles (Box 2.3) underpinning all aspects of its activity. Translating this to the establishment of collaborative activities formed a priority for the Programme, particularly during its early stages:

"…in the early stages of its life, the Programme Board (in particular) explicitly considered how collaboration could be promoted through the various activities it sponsored. There can be no doubt that this strategic driver towards collaboration generated a large number of projects that involved a spectrum of engagement and partnership with a wide range of organisations and individuals both within the high sector and more widely." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

11. With the Programme's activities being focused around six Spoke higher education institutions at its outset[1], there was a need for its work to engage more widely with other universities; the engagement achieved has been widespread:

"The fact that 81 different HEIs have led a project and an additional nine have been engaged as a collaborative partner shows a high level of engagement with the Programme, covering the majority of HEIs with relevant STEM provision in England and Wales." CFE, Summative Evaluation of the National HE STEM Programme (2013)

Additionally, collaboration has been successfully achieved across all three strands of Programme activity and enhanced the activities undertaken:

"Many of the projects involved HEIs working in partnerships – sometimes in association with a professional body (e.g. IOP, MSOR and RSC). This collaboration helped to further the development process, facilitate practice transfer and advance professional learning." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

"New networks and partnerships within, between, across and beyond HEIs have been established through carrying out the multi-institution projects funded by the Programme." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

[1]Five further universities were involved in components of activity at the Programme's outset. The Universities of London South Bank and Leicester with Integrated Sciences, Salford with Repackaging Physics, Loughborough with **sigma** and the work undertaken by the Engineering Subject Centre, and Coventry with **sigma**.

"Analysis of available project data suggests that collaboration within the Programme has been effective, in that it has established professional relationships between many organisations that may not normally have worked together. The majority of projects involved some form of external collaboration or partnership working." CFE, Summative Evaluation of the National HE STEM Programme (2013)

12. As well as enabling wide engagement with the Programme's activities, collaboration has also helped to ensure its activities have not duplicated those of existing STEM initiatives and organisations:

"The pilot projects and the National HE STEM programme largely avoided excessive duplication, facilitated in part by working with organisations such as the National STEM Centre." Evaluation of HEFCE's Programme of Support for Strategically Important and Vulnerable Subjects, HEFCE (2011)

"A positive development is that the HE STEM programme has been working with the National STEM Centre and STEMNET to coordinate activities." Evaluation of HEFCE's Programme of Support for Strategically Important and Vulnerable Subjects, HEFCE (2011)

Building Upon Existing Networks and Collaborations

13. An important feature of the work of the Programme was that it sought to base its activities around existing organisations, networks and collaborations where these would offer a mutually beneficial starting point. Such an approach formed the basis for the wider transfer and embedding of pilot project outcomes, but was equally prevalent across all three strands of Programme activity. Adopting this mode for delivery, particularly within the early stages of the Programme, not only meant that as a proven starting point or a way of working existed it was more likely to be effective within the timeframe of the Programme, but also that activities could be initiated for a lower cost but still with the potential for more substantial outcomes.

14. An area where this approach was particularly evident was the work of Programme partners with the National STEM Centre, the Science Learning Centres and STEMNET on activities focused around working with those currently within the school and college sectors:

"Feedback from the National STEM Centre at the University of York also emphasised that the National HE STEM Programme had delivered consistently on its aim of working in partnership with existing STEM-focused organisations; this approach is also evident in the close working relationship with STEMNET." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

15. One of the reasons for such successful engagement was at the time the National STEM Centre led a STEM Cohesion Programme[2] which was created as a means of bringing together the many stakeholders who supported the teaching and promotion of STEM subjects on both a national and regional basis. When the National HE STEM Programme was established, the Programme's Hub was invited to participate in the national group, and Spokes in the regional groups. This resulted in the natural introduction to key individuals involved in both regional and national STEM activity, and consequently led to the development of working relationships that gave rise to collaborative activities.

16. Furthermore, each Spoke facilitated its own regional steering group throughout the duration of the Programme, and regional meetings were held at the Programme's start to generate buy-in and engagement with key stakeholders. At the University of Bath for example, an employer member of its University Council was nominated to join the regional steering group, and as such this individual was able to make external links and promote the Programme in discussion with other key internal and external stakeholders.

17. As a consequence of such successful engagement, all Spokes have undertaken activities focused upon enhancing the activities of higher education institutions with schools and colleges in collaboration with existing STEM sector organisations with similar mission statements. It is perhaps important here to make an important distinction: the role of the Programme has not been to fund the continuation of existing activity, but instead has involved either adding a higher education specific context to extend the existing activities taking place or engaging universities who had previously not participated in such activities. In either case, the role of the Programme was to engage the higher education sector with existing STEM sector activities to enable a more coherent and complementary approach whereby mutually beneficial value was added.

18. Within the Spoke regions of the Programme, a number of projects utilised the regional Science Learning Centres as the focus for their activities, including engaging them to lead projects. The STEM@Work project consisted of a partnership of five higher education institutions, led by the Science Learning Centre at Durham University, and challenged school students to learn about STEM careers and pathways by working with the universities and STEM businesses that supported the project.

19. Programme Partners have also worked with the Science Learning Centres to share their expertise more widely across the STEM sector and in new contexts. The Science Learning Centre South East worked with the RAEng, the London & South East Spoke, and National Grid to provide professional development activities to enhance teachers' knowledge of careers in engineering. National Grid has now committed to fund further events across the country and the Science Learning Centre South East is utilising this model to generate income from further corporate organisations. In the North West, the Science Learning Centre provided professional development to academic members of staff and postgraduate students from the Universities of Manchester, Central Lancashire, Lancaster and Manchester Metropolitan to enhance university led outreach activities.

20. In other instances, the high quality facilities offered by the Science Learning Centres have formed an appropriate location from which Programme activities can be delivered. Connect to Science at the University of York [Case Study 25] provided a pathway for disengaged adult learners to

[2] https://www.education.gov.uk/publications/eOrderingDownload/DFE-RR147.pdf

learn more about opportunities for education and employment in the STEM disciplines, and to encourage progression to other courses or to enter STEM related employment. A total of 68 learners participated during the seven occasions the course was run, and the project was nominated for the Vice Chancellors Gold award for Inclusivity.

21. The project has not only enhanced the visibility of the National Science Learning Centre by making it accessible to non-traditional learners, but has led to the development of an ongoing collaboration:

"This project has led to an enhanced working relationship between CLL [Centre for Lifelong Learning] and the National Science Learning Centre, and work is already underway to offer a 10 week evening class programme to parents of key stage 3 and 4 pupils so that they can better support their children's careers aspiration in STEM related topics, entitled 'Science is for Parents Too'." [Project Report, Connect to Science, University of York]

Similarly a project led by the University of Leicester to implement the RSC's Outreach Package was undertaken as a regional collaboration with the delivery of activities taking place at the regional Science Learning Centre:

"The activity was run as a collaborative event hosted by the Science Learning Centre East Midlands (SLCEM) and delivered by the Universities of Leicester, Loughborough, Nottingham, and Nottingham Trent, along with an industrial partner, AstraZeneca… we were able to recruit 40% more pupils to attend and thus fill the SLCEM venue to its maximum capacity. Its popularity continues, and it will run again on 14 March 2012 subsidised by the Royal Society of Chemistry." [Project Report, Chemistry Outreach package, University of Leicester]

22. Such a regional approach to outreach in the East Midlands was implemented through an earlier project which sought to share effective practice arising from, amongst others, Chemistry for our Future, Stimulating Physics, and the Centre for Effective Learning in Science. The project took a unique approach by offering a STEM outreach event for schools and colleges but with a parallel structured programme for higher education representatives on how to design and run activities in a range of STEM disciplines. This model allowed higher education staff to witness the activities with schools and colleges and then receive advice, guidance and support to enable them to successfully implement these elsewhere.

"A key outcome was that people got to share their passion for communicating STEM subjects. It is important there are national and regional events where HE STEM outreach workers can share best practice and pass on skills and ideas to others with hands-on workshops. This whole project had been dedicated to equipping HE staff with the tools and inspiration to implement good practice more effectively within their own institutions… At NTU the work of CELS in coordinating outreach for science and technology has been built into the School Academic Plan for 2010 onwards. This should ensure that similar activities take place in the future." [Project Report, Sharing Best Practice in STEM Outreach, Nottingham Trent University]

23. In Wales the situation was somewhat different:

"The situation in Wales is further exacerbated by the notable exception of a regional science learning centre." [External Evaluator, Accredited STEM Careers Module, Cardiff University]

However, the partnerships established through the Programme meant three universities in Wales (Cardiff, Glamorgan and Swansea) were able to work with the National STEM Centre, the National Guidance Research Forum (University of Warwick), and Sheffield Hallam University to develop and deliver an accredited STEM careers module for careers professionals [Case Study 5].

24. STEMNET was another key organisation with whom Programme partners worked closely, particularly in relation to furthering student ambassador type schemes within the higher education sector, and supporting school based STEM clubs. In the Midlands and East Anglia, four higher education institutions were encouraged to work with clusters of afterschool STEM clubs through a sustained series of linked activities [Case Study 13]. In Wales, a similar approach implemented Saturday science clubs for girls within two new higher education institutions based upon a model originally developed by Cardiff University and Careers Wales Cardiff [Case Study 4].

"Activities will continue in a broadly similar format to deliver and support the school clubs with newly recruited University students as STEM Ambassadors." [Project Report, Science Working for You: STEM Cluster Initiative, Staffordshire University]

"The approach proved successful due to the close collaborative partnerships with stakeholders. Working with networking organisation such as STEMNET and identifying staff from both schools and the university to champion the project proved invaluable." [Project Report, Why don't you stick it on the wall? Professionalising STEM club outputs, University of Wolverhampton]

25. Across the Programme undergraduate and postgraduate students and university members of staff have been recruited to become STEMNET Ambassadors. Such ambassadors have been trained and supported in conjunction with STEMNET, for example physics buskers at Aberystwyth University, and the training sessions have also been utilised to disseminate the interactive resources from the more maths graduates project in the form of the Maths Ambassador Resource Kit.

"Working with STEMNET we have trained 14 undergraduates as STEM Ambassadors assisting with the STEM workshops, annual Science Festival and Science projects in local Primary schools. STEMSoc undergraduate society, assisted by the Student's Union will start in September 2012 for students across all disciplines of STEM at the University. Members will have opportunity to become STEM Ambassadors to assist with outreach activities, have access to STEM industries for project work and internships and the option to complete a 20 credit 'Science Communication' module." [Project Report, Self Sustaining STEM Networks, University of Chester]

26. During the delivery of activities focused upon working with schools and colleges, many universities utilised Aimhigher networks (See Section 5) to enable their activities to be more appropriately targeted towards widening participation cohorts. The closure of the Aimhigher programme on the 31 July 2011 was noted as a significant loss by several Programme partners, but recognising the value of the expertise contained within the Aimhigher initiative, a series of regional events were undertaken to share this learning more widely:

"I have a better grasp of how what Aimhigher did can benefit me now."

"I understand more about targeting now, but I don't think it is less of a challenge though"

"I think I now have a better appreciation of how contested the area of targeting is theoretically" [Delegates, Sustaining the Impact of Aimhigher Workshops]

27. Following on from these workshops, and furthering a project initially initiated at the University of Exeter which created a community of practice for outreach and widening participation practitioners [Case Study 13], a national community of practice project was launched [Case Study 14] in the final year of the Programme led by AccessHE, a division of London Higher, the umbrella organisation for higher education institutions in London. This project undertook an array of work to build a case for collaborations between HEIs and third sector organisations in the field of STEM outreach including: providing grants to five separate third sector organisations (@ Bristol, Space Connections, Teach First, Villiers Park and Generating Genius) to develop models of collaborative STEM outreach; creation of a national forum of higher education institution and third sector practitioners that met on three occasions to guide delivery of the project; a national conference in London; research feeding in to the publication of a report, 'Unblocking the pipeline: How the third sector can increase HE participation in STEM subjects', to inform policy debate; and the establishment of five regional communities of practice to enhance local higher education and third sector collaborations. The activities of the national and regional communities of practice continue:

“The South West CoP will continue in a modified form…at the University of Bath, working with third sector organisations. In addition, the HEI-third sector community of practice project that has overseen the establishment of five regional CoPs and one national one will continue into 2012 – 2013.” [Project Report, Developing a Community of Practice for STEM Outreach and Widening Participation Practitioners, University of Exeter]

28. A range of other STEM organisations have worked collaboratively with the Programme supporting the delivery of the activities undertaken. Buttle UK provided support to the regional Looked After Young People project in the North East and also provided an opportunity for dissemination at its annual conference. The Birmingham Centre for Railway Research and Education ran a four-day residential event for 37 school pupils in July 2011 in conjunction with the Smallpeice Trust; this activity was offered again in 2012, and is also scheduled to run in July 2013[3]. The Smallpeice Trust also offered free access to experiences and summer schools to students from the Somali community in London as part of the Somali Saturday Schools project led by the University of Southampton.

29. In Wales, over 350 Year 9 girls participated in the Engineering Education Scheme for Wales Discover Engineering Days for Girls project [Case Study 4]. Similarly, the Medical STEM and the related STEM A-level Enhancement projects organised by the South West Wales Reaching Wider Partnership based at Swansea University enabled residential visits to the University for 90 targeted pupils from Communities First backgrounds:

“The work has encouraged a focus on STEM subject areas and has complemented themes recently requested by HEFCW within the Reaching Wider 3 year strategy. Furthermore, it has offered the opportunity of placing a STEM element within the Reaching Wider’s core Summer University model…The workshops have already been adapted and simplified to be delivered to year 10 students as an extension of the current Year 12 model.” [Project Report, Medical STEM & STEM A-Level Enhancement, Swansea University]

30. Avoiding duplication of, and adding value to, the school and college focused activities of existing STEM organisations and initiatives was perhaps the Programme’s greatest driver for its approach towards collaborative working. However, opportunities to build upon existing collaborations and networks were realised across the Programme’s other two strands of activity as well.

31. For the higher education curriculum focused activities of the Programme, a key collaborator was the Higher Education Academy and in particular its STEM Subject Centres. Two Subject Centres (Mathematics, Statistics & Operational Research and Engineering) were involved outright leading curriculum innovation and enhancement activities in these discipline areas, but representatives from other Subject Centres were engaged in the delivery of activities. For example, a representative from the Physical Sciences Subject Centre led a project to establish a full chemistry degree by distance learning at the University of Hull [Case Study 61], and representatives from the Materials Subject Centre led the development and wider dissemination of a diagnostic tool for assessing aspects of the knowledge and experience of incoming engineering students.

32. At the end of 2011, all Subject Centres closed, and this change proved particularly challenging for the Programme as it disrupted the dissemination plans of many projects who had committed, in their proposals, to undertaking dissemination in a coordinated manner through their Subject Centre. With the closure of the Subject Centres, the Higher Education Academy moved to a new delivery model which became increasingly operational over the final year of the Programme. Despite attempts to do

[3] http://www.smallpeicetrust.org.uk/index.php?option=com_content&task=view&id=1274&Itemid=494

so, it proved not to be possible to bring together members of the National HE STEM Programme Team with their counterparts in the Higher Education Academy. While some collaborative activities were undertaken, for example, the Programme participated in the planning and delivery of the inaugural Higher Education Academy STEM conference in April 2012, there was perhaps a missed opportunity to integrate some project leads who had not previously engaged with the Higher Education Academy with their work. Nevertheless, the University of Birmingham continues to work with the Higher Education Academy in 2012/13 to further build upon the work of the Programme through a series of national activities.

33. Within the Programme's higher level skills activities, discussed in detail in Sections 6 and 7, a number of projects worked closely with the Sector Skills Councils, in particular SEMTA and Cogent, and employer organisations. The Labour Market Intelligence project led by the University of Exeter involved both SEMTA and COGENT along with a regional Employment and Skills Partnership. The project comprised six sub-projects designed to address specific challenges in employer engagement experienced by STEM related departments and/or colleges within the Universities of Bath, Exeter, Plymouth and the West of England and the further education colleges of Petroc and Weymouth. The Engineering Employers Federation and COGENT took an active role in discussions with partners on employer engagement and contributed to a 'Creative Learning Journey' process[4]. In Wales, the UPSKILL project [Case Study 57], worked in partnership with the Welsh Optoelectronics Forum, SEMTA and the Photonics Academy for Wales, to define the Photonics skills training requirements of identified SMEs and micro-enterprises and then develop exemplar learning techniques and materials to meet these generic requirements.

34. At the University of Huddersfield, the Succeeding in Tomorrow's Engineering World of Work project was delivered in collaboration with the University of Bradford and Bradford College, and built upon work previously undertaken by the Institute of Mechanical Engineers and the West Yorkshire Lifelong Learning Network. The project delivered a complementary, and now sustainable, mix of intervention activities in order to provide a range of individuals with the skills needed for engineering and manufacturing in the local region. Ten CPD short courses, including project management and communication skills, were piloted with 149 students to equip them with the transferable skills necessary to smooth the transition from academia to industry. A further activity designed and developed an industrial mentoring module in conjunction with SEMTA which resulted in 17 students participating in placements:

"Working with the HE-STEM project, the WYLLN [West Yorkshire Lifelong Learning Network] and Bradford College has been instrumental in developing new curriculum and support networks for the nationally important subject of Casting. This support has helped generate a critical mass and ensuring a sustainable partnership to be established." [Institute of Mechanical Engineers Representative, Succeeding in Tomorrow's Engineering World of Work]

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[4] http://www.creativestem.co.uk/#

35. Through the Programme, some existing networks have been extended as a natural consequence of the activities that have been undertaken. The Engineering Gateways Practice Transfer Partnership [Case Study 60], led by the Engineering Council, built upon an existing framework for flexible and innovative higher education provision for engineering employees that resulted in a professional engineering qualification (IEng or CEng). Five universities implemented the framework and collaborated with five existing providers who shared their practice. In addition to the development of a toolkit to support other universities wishing to implement this framework, five new engineering gateway degrees have been created, and the size of the community of practice has grown:

"All five universities are either already marketing, or will be marketing, an Engineering Gateways type of degree. This brings to twelve the number of providers of Engineering gateways type degrees, which increases the size of the community of practice…Two of the new providers are offering a discipline hitherto not available (building services engineering) to the workforce and for which there is a perceived need." [Engineering Council Representative, Engineering Gateways PTP]

Developing New Networks and Collaborations

36. While the Programme sought to build upon existing networks and collaborative groupings where possible, a range of new networks were established developing links between and within higher education institutions. While all Programme partners contributed to the development of these collaborations, the Professional Bodies were ideally placed to broker and develop national and regional relationships, and this helped enable the national transfer and embedding of the developed pilot project practices:

"Although collaboration between HEIs in an increasingly competitive HE environment has been challenging, there are good examples of the Programme supporting and encouraging collaboration and the Programme also fulfilled its aim of disseminating good practice from the pilot projects and other institutions more widely across the sector." CFE, Summative Evaluation of the National HE STEM Programme (2013)

"New networks and partnerships within, between, across and beyond HEIs have been established through carrying out the multi-institution projects funded by the Programme. Additionally, the dissemination and promotion of these projects at various HE STEM events across the country has enabled more people to learn about the projects, and the work interests of people associated with these projects." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

37. The national roll-out of the Spectroscopy in a Suitcase (SIAS) scheme [Case Study 7], which made available portable spectroscopic equipment to schools through trained undergraduates, postgraduates and academic members of staff, was extended from four participating universities (in two Programme regions) at the start of the Programme to nineteen (in all regions) by its conclusion. The RSC facilitated regular meetings of the participating universities which not only helped to ensure cohesion and consistency of delivery across all regions, it also contributed to the development of a network for the sharing of ideas and support. Making use of existing networks

was an essential aspect of the success of the SIAS initiative. RSC networks such as the School Teacher Fellows and Regional Coordinators, as well as regional consortia developed for outreach purposes, enabled new partners to become established rapidly with minimal lead-in time; this also proved an effective means of raising awareness of projects within a region. This networking approach has also been employed for the School Teacher Fellows engaged through the Programme:

"As one STF commented: 'That [impact] just wouldn't have happened without these networks and the RSC to just get everything started…They were very keen on that, to think about the impact. Because previously it had just been within the institution and within the department'…A 'School Teacher Fellows Project Collaboration Group' has been established that will allow aspects of the work undertaken by the project to be continued." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

38. In September 2011 the IoP held a conference for all physics outreach officers in UK higher education institutions with the intention of creating a network of practitioners who have, or wish to have, strong outreach links with their local schools and are interested in sharing experiences and networking with colleagues in similar roles. In total 67 delegates participated in this inaugural meeting, with around 33 universities and national research labs represented. Two further conferences have since been held[5] in May 2012 and November 2012 of this Schools Outreach Support Network which is further supported by an email discussion list.

39. A similar approach of networking and collaboration has not only helped the wider transfer and embedding of Context and Problem Based Learning (C/PBL) activities developed within the Stimulating Physics and Chemistry for our Future pilot projects, but also their further development (Section 6). In the mathematical sciences, the curriculum innovation and enhancement strand of activity led by the Maths, Stats & OR Network was established by first holding a 'Mathematics HE Summit' which was attended by Heads of Mathematics or their representatives from 26 universities offering mathematics degrees (approximately 50% of those in England and Wales), and a range of other disciplinary stakeholders. The summit presented findings from the curriculum strands of the More Maths Grads pilot project, and was used to develop priorities for curriculum development which were then implemented across the community[6]. This approach ensured that the activities undertaken were not only those that were needed, but ensured there was a high level buy-in to the planned work at its outset, and provided tangible opportunities for mathematical sciences departments to engage with the work of the Programme.

40. The national roll-out of SIAS also provides an example of the effective collaboration between the Professional Bodies and Spokes to transfer and embed the learning from the disciplinary pilot projects. One of the first projects undertaken by both the North East and North West Spokes was to support the installation of the SIAS kits into all Yorkshire and Humber higher education institutions, and both Manchester (University of Manchester and Manchester Metropolitan University) and Liverpool (Liverpool John Moores University and University of Liverpool) regions. Further support was then provided by the Spokes to make available a number of training sessions for university staff and students in how to use the suitcase with schools and young people. The SIAS initiative has also now been extended into Wales with equipment based in North (Bangor University) [Case Study 23]) and South Wales (Cardiff University), and the guidance materials have been translated into Welsh to enabled increased engagement and inclusivity.

[5] http://www.iop.org/education/higher_education/stem/outreach/page_51786.html

[6] http://mathstore.ac.uk/headocs/MSORConnections113_0.pdf

41. A similar approach enabled the RAEng to work with the Spokes to embed five large-scale regional outreach projects that incorporated, and build upon, the work of the London Engineering Project [Case Study 2]. The approach of the RAEng working with Spokes resulted in the engagement of over 30 higher education institutions with these regional activities:

"The eight HEI partners were sourced after a detailed scoping exercise in consultation with The Royal Academy of Engineering…" [Project Report, Professor Fluffy Explores Engineering, University of Liverpool]

The RAEng was also active in the Nuclear Island project [Case Study 52] which it led jointly with COGENT. In addition to securing additional funding from the UK Commission for Employment and Skills (UKCES) to extend the model to apprentices and employees, additional universities engaged with Constructionarium[7] to offer hands-on learning opportunities to their undergraduate students.

42. The Industrial Group Projects initiative [Case Study 36] was a scheme that initially involved the physics departments in nine universities adapting and rolling out an approach that had been running successfully for 20 years as an integral part of the undergraduate curriculum at Durham University. Through the scheme, third-year undergraduate students worked together in groups to solve real problems set for them by industry, thereby helping them to gain transferable skills. While the project was managed by Durham University, the IoP played a key role by supporting universities to work together to share ideas and good practice, and by producing and disseminating guidance and advice for others wishing to participate; additionally, the IoPs' role in accreditation meant that it could 'steer' university departments towards the scheme:

"Networking between universities was a feature of the implementation of the GIP – meetings providing an opportunity for the sharing of ideas. There was also a Google site onto which the project manager had uploaded resources and a Google forum was set up to facilitate interaction online…" Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

To date, a total 19 physics departments have participated in the Industrial Group projects initiative; 9 ran the scheme in 2011/12, engaging 75 students, and a further 10 are running the scheme during 2012/13. The IoP is continuing to support participating higher education institutions.

43. A similar national network was developed to provide support and share effective practice in relation to university wide mathematics and statistics support. The **sigma** Mathematics and Statistics Support Network [Case Study 29] has built upon work undertaken previously by the Centre for

[7] http://www.constructionarium.co.uk

Excellence in Teaching and Learning (CETL) at Loughborough and Coventry Universities. Through the network, 22 higher education institutions have been able to implement mathematics and statistics support centres [Case Study 28] based upon a well researched and proven model. Each university now has a means of enhancing the learning experience of students who struggle to cope with the mathematical and statistical components of their course, particularly as they make the transition to higher education study. The importance of mathematics support was further reinforced during the course of the Programme when the IoP published its 'Mind the Gap' report[8] which explored the transition from A-levels to physics and engineering degrees:

"A large proportion (92%) of academics felt that a lack of fluency in mathematics was an obstacle to students achieving their full potential in the long term, and more than four in five (85%) agreed that a lack of fluency affected their department's ability to deliver an optimal programme of study." Mind the Gap, Institute of Physics (2011)

44. In addition to the creation of the Centres, a national network of staff and institutions across the higher education sector has been established that continue to work collaboratively to share learning and resources. A key feature of this network is the creation of six regional hubs, aligned with the National HE STEM Programme regions, that allows participants to access dissemination events and gain access to expertise at a regional level. When the second series of (nine) mathematics support centres were established, the **sigma** network provided a natural means of supporting those who were new to this area:

"…the call for proposals and subsequent events organised within the sigma **network have stimulated the development of the centre, and provided access to a generous network of like-minded individuals willing to share their expertise and experiences in similar projects at other universities." [Academic Member of Staff, Mathematics Support Centre, University of Warwick]**

"This would not have been possible without the support we received from sigma **to help set this up. Of most use to us was our mentor who was happy to share their mistakes, so we could avoid them and gave practical advice that will give us the best chance of sustaining our mathematics support programme." [Academic Member of Staff, Mathematics Support Centre, University of Wolverhampton]**

45. The network has, in particular, enabled collaborations between the new centres on a regional basis. For example, in September 2012 the University of Birmingham organised a regional training day for postgraduate students seeking to work in its mathematics support centre that was also attended by postgraduate students from the Universities of Keele, Warwick and Wolverhampton.

[8] http://www.iop.org/publications/iop/2011/file_51933.pdf

"When I started working at the University of Exeter in 2009, part of my job role was to build on and expand the mathematics and statistics support available for students. I was immediately put in touch with the sigma**-sw hub…Apart from events organised through the hub, I have also benefited from the research, training, resources and professional advice which** sigma **has provided over the past three years. Our mathematics and statistics support project has now received permanent University funding and I am sure this would not have happened without us having access to the** sigma **network."**
[Academic Skills Advisor, Mathematics Support Centre, University of Exeter]

46. Another feature of the work of **sigma** has been to establish a series of guides and resources for those new to setting up mathematics support centres, or those seeking to enhance current practices. The guides are freely available online as part of an ongoing series of mathematics and statistics support materials[9].

47. All six regional hubs have identified definite plans, or already undertaken the delivery of activities, to ensure the network is maintained and remains visible, and a steering group of active mathematics and statistics support practitioners has been established to continue its development. The **sigma** network will also ensure that the CETL-MSOR Conference, first established by the Higher Education Academy Subject Centre for Mathematics, Statistics and Operational Research in 2006, continues in 2013 despite the closure of the Subject Centre.

48. Of the 22 new mathematics support centres that were established, 8 of these were located in Wales following a decision by the Spoke to embed the practice more widely in response to the work of **sigma**:

What has been most valuable has been the experience and expertise which sigma **has shared enthusiastically with us at each stage of the process in relation to resources, materials, how to organise a centre, training of students who helped in the centres, and dealing with challenges faced by the support centres in their first year of operation. Without** sigma **we would have been unable to achieve the significant progress in Wales to date on making mathematics support available to more STEM students in higher education. [Wales Spoke Director, Swansea University]**

49. The Programme's Spoke partners have been equally active at establishing partnerships and collaborations, firstly on a regional basis, but then more widely as work to transfer project outcomes commenced in the latter stages of the Programme. Although the North West Universities Association (NWUA) was a pre-existing grouping of higher education institutions aimed at fostering collaboration between its twelve members, it provided an ideal mechanism for establishing the Programme's higher level skills activities within the North West through two linked approaches. The first involved the development of a pre-existing resource to establish a STEM Business University Gateway [Case Study 58]; this now provides a clear access route to information for employers seeking to engage with higher education institutions. In parallel with the development of the Gateway, a gap analysis was undertaken to identify STEM industry needs in the North West which was then used to develop a series of regionally coordinated professional development modules for those in the existing workforce [Case Study 59].

50. While both activities were led by NWUA, their work was firmly embedded within the higher education sector. This proved essential when NWUA announced it would be ceasing its operations at the end of June 2012. Manchester Metropolitan University has committed to not only maintaining

[9] http://www.mathcentre.ac.uk/topics/mathematics-support-centres/mathematics-support-centres-2/

the STEMBUG Gateway but also furthering its development. For the CPD provision, a suite of 26 modules (ranging from 5-20 credits) across 5 HE providers addressing the needs of the aerospace, automotive, engineering, energy, textiles and construction sectors has been developed. Some of this provision is delivered collaboratively. For example, Liverpool Hope University, the University of Salford and the University of Central Lancashire are working in partnership to provide a suite of mathematical provision for STEM industries.

51. The Programme's activities to increase and widen participation in higher education from traditionally underrepresented groups of learner have resulted in new collaborations between higher education institutions. While they will be discussed in more detail within Section 5, both the Looked After Young People and Generating Genius projects have developed increased or enhanced relationships between higher education institutions in the North East and London & South East Programme regions.

52. A number of curriculum focused activities were also collaborative in nature, and perhaps a significant influence in this approach was the philosophy towards collaboration and shared working that had been previously established within the sector through the Higher Education Academy Subject Centres:

> **"…colleagues have an opportunity to share their ideas with others, without the need to write up a formal article, and to make contact with other staff with similar interests." [Project Report, Improving Feedback in HE Mathematical Courses, Sheffield Hallam University]**

53. All Programme partners have undertaken a range of dissemination activities to share the learning emerging from activities and projects more widely. Dissemination activities of the Programme have proved particularly effective at inspiring, stimulating and realising subsequent collaborations:

> **"We are now looking to forge links with London Metropolitan University following the successful Maths in a Box session…We are looking to explore a mentoring programme, linking young people with Maths undergrads, who would offer additional support through after School or Saturday School Clubs." [Member of Staff, Skills Unit, Essex County Council]**

> **"The University of Bristol has just been awarded a small grant (led by the University of the West of England) from HE STEM on sharing learning between the two institutions about engaging the local Bristol community. This grant is a direct outcome of discussions at dissemination events from this project." [Project Report, The challenges and opportunities of incorporating community based learning into STEM subjects, University of Bristol]**

> **"One result of the successful symposia is the strengthened cross-institutional working partnership that has developed between both staff and students at Imperial and Loughborough. With the initiation of the national student led projects community it seems likely that this relationship will continue indefinitely and the project will not only be sustained, but also significantly expanded." [Project Report, Showcasing and extending student-led employer-focused extra-curricular activity, Loughborough University and Imperial College London]**

54. While there is often a focus upon encouraging collaborations between higher education institutions, often overlooked is the need, or benefit, or facilitating collaborations within individual institutions. There often exist effective approaches with the potential to be transferred between disciplines, like-minded individuals who wish to collaborate to achieve mutually beneficial goals, or access to particular expertise that might enhance the activities undertaken. The barriers to internal collaboration appear to mirror those of wider inter-institutional collaboration which is typically due to a lack of awareness of the activities taking place rather than an unwillingness to collaborate. As universities are large organisations, bringing like-minded individuals together, either formally or informally, can have beneficial results:

"There are plans for the School of Physical Sciences Outreach Group (in development) to collaborate with a colleague from Environmental Sciences to develop outreach programmes (it is unlikely we would have met if she had not heard about this event and registered)" [Project Report, Doing Outreach, University of Liverpool]

"The outputs of the project have been communicated both externally (via the dissemination meetings) and internally, for example at a public engagement course for academics in probation at Bath, the latter leading directly to staff development." [Project Report, Embedding Accredited STEM Communicator Models, University of Bath]

55. Developing collaboration and sharing learning within institutions has been successfully achieved through the Programme; understanding how it has been achieved is an important learning exercise. Evidence suggests that while a range of approaches have been effective, a dominant factor has been the actions of Programme partners in providing the necessary framework for internal collaborations to be fostered following the identification of 'networking' as a strategic priority for the Programme. Partners actively encouraged project leads to participate in, or establish, institutional events, conferences or seminars, and organised events within institutions to bring project leads together along with other interested partners. Another approach has been to rotate dissemination events between higher education institutions and encourage project leads from the host to participate, while others have encouraged internal steering groups to be formed:

"Collaboration between the faculty and the central Careers and Employment Service has led to other valuable learning outcomes which can inform future development. The Careers and Employment Service has worked over a number of years to establish its generic Career Mentoring Scheme and, although having been successful in its task… has worked in relative isolation for most of that time. Establishing a Steering Group for the purposes of this project has been invaluable for identifying a plan that integrates the scheme within the fabric of the faculty, helps to identify key influencers within the faculty and, at course level, has helped to get the scheme included in a number of faculty events (such as an Industry Day and Engineering Conference) and involved in developing a Women's Engineering Network." [Project Report, Developing Employer Engagement in STEM Through Career Mentoring, Sheffield Hallam University]

56. The Programme's approach has been effective at generating a range of new, and sustainable, collaborations:

"This is the first App that has been developed through collaboration between the Science Faculty and the Learning and Teaching Solutions support team at the OU." [Project Report, Unclear About Nuclear?, Open University]

"We will continue to convene the university wide STEM group three times a year...The group will monitor STEM activity and on an annual basis the activity will be evaluated and the annual calendar of events refined. We will use the templates we have developed to apply to the delivery of other STEM activity. We will circulate opportunities (conferences/funding/collaborative projects) within the group and monitor the school curriculum so we can match our offer to the schools and colleges needs." [Project Report, Delivering STEM Outreach: Partnership Working in the University of East London, University of East London]

57. During the Programme, each Spoke was asked to establish a significant 'Legacy Project' designed to ensure a long-lasting legacy for the Programme's work within the institution; while the particular focus of each project was for the Spoke to determine, the requirement existed that projects were based around the Programme's higher level skills strand of activity. For a legacy to be achieved, several projects engaged in extensive collaborative activity within their institutions; enabling such an approach was a key feature of their design:

"The Legacy projects overall have demonstrated collaboration with staff across university departments such as employability and careers services, the Alumni Office to identify external/employer contributors, technicians, and facilities management staff." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

58. The University of Bath Legacy Project was developed in consultation with a number of key University staff in order that it could build upon and extend existing good practice within the University and further afield in relation to embedding employer engagement across the undergraduate STEM curriculum. The project engaged with the University Careers Service, Alumni Office, Placement Support teams, Student's Union JobLink, Bath Award and SORTED organisations; this ensured a fully cohesive approach was taken towards delivery. One outcome from the project was an employer led development skills programme, embedded within the relevant degree timetables as a compulsory session, taken by approximately 100 science students in 2011/12, and linked with other University-wide activities; an associated mentoring scheme, currently involving 22 graduates, was also developed and rolled out across the University:

"The programme has successfully engaged with industry and has secured presenters for the new academic year. The programme will become credit-weighted, to ensure student attendance. The programme will continue to develop through the exploration of Moodle/Mahara integration, which will provide an assessed e-portfolio for each individual student." [Project Report, Strengthening, Extending and Embedding Employer Engagement, University of Bath]

59. The University of Bradford's legacy project [Case Study 54] brought together two strategic institutional initiatives, STEM and sustainable development, with a focus upon promoting, as well as developing awareness and increased understanding of, sustainable development within STEM subjects amongst both staff and students. The project resulted in significant changes to a number of programmes, not only at Bradford but also the University of York and Leeds Metropolitan University. Additionally the project led to the establishment of the inaugural S-Lab ('Safe, Successful and Sustainable Laboratories') Conference and awards in June 2012 at the University of York. This conference will be held again in June 2013 at the University of Liverpool[10]:

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

60. In a similar approach, the University of Birmingham's Grand Challenge legacy project (Case Study 53), which established a mechanism for a substantial interdisciplinary activity to be undertaken in conjunction with employers and enables students to propose solutions to an open-ended, real-world issue, was based around collaboration within, and external to, the University. A range of central University teams developed and delivered complementary sessions to students and supported them during their four-week (full-time) project, and students from Aston University participated in the 2012 Grand Challenge. Through collaborations developed within the Programme, the Grand Challenge has now been rolled out to the Universities of Nottingham Trent and Aston:

"Grand Challenge is now being adopted by Aston University and Nottingham Trent University: the same 4-week programme is to be developed by Aston as part of the careers and employment service provision and at Nottingham Trent within its employability skills module as a 2-week programme." [Project Report, Grand Challenge, University of Birmingham]

61. At Manchester Metropolitan University the legacy project sought to address the identified regional need for technical workforce up-skilling, specifically within the process industry sector, by working in close collaboration with various stakeholders who have strong links and access to employers, including the Sector Skills Councils, National Apprenticeship Service, National Skills Academy for the Process Industries, and other training providers:

[10] http://www.effectivelab.org.uk/effective-lab.html

"…a partnership with Macclesfield and South Cheshire colleges has resulted in a new franchised FdSc Applied Science programme being set up. This has now been implemented, where one of the colleges are running the programme (under the MMU banner) with an in-take of 9 students." [Project Report, Developing STEM up-skilling services for the process industries in the NW, Manchester Metropolitan University]

Transfer and Embedding Effective Practice

62. Collaboration, shared working, and networking has been the primary means of developing, and transferring and embedding effective practice within the Programme; this is equally true for the way of working of Programme partners as it is for established projects and activities:

"Furthermore interviewees reported that the creation of the regional Spoke structure had, in some cases, facilitated mechanisms for more extensive sharing materials and 'kit' especially in relation to widening participation/outreach initiatives. In some cases the Spokes had funded the purchase of additional sets of these materials which would continue to be used in the future. In addition interviewees identified that the national HE STEM Programme Board had given the Professional Body/Learned Society viewpoint an opportunity to develop and contribute a shared 'voice' on strategic issues." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

63. While The Programme Board provided a means of coordinating activities and developing collaborative approaches, membership was restricted to Spoke and Professional Body Directors. The three Special Interest Groups (SIGs) were established to bring together Programme Officers working on similar areas and strands of activity to provide a degree of coordination and to support dissemination. Each SIG adopted a different approach to meet the needs of its activity area, and although the group meetings did not involve external members as originally envisaged, all SIGs provided an opportunity for members of the higher education STEM sector to participate in their activities.

64. The Careers, Workforce Development, and Lifelong Learning SIG, in response to institutional requests for professional development in the field of employer engagement set up a series of workshops in association with specialist trainers (Bibby Rumbleow Ltd.). Five workshops ran between January and May 2011, and over 110 people participated from 12 institutions. Project leads found these workshops beneficial to support their activities:

"As a result of attendance at a series of master classes on engagement of employers (Bibby Rumbelow 2011) it was decided to appoint an industry chair of the IAB and this proved to be a good idea." [Project Report, Applied Physics, University of Portsmouth]

Additionally, the SIG organised briefing meetings, consisting of Programme partners and other key national stakeholders to support the development of the Programme's higher level skills activities through the Regional Action Plans; briefing documents for use by Partners were also subsequently produced.

65. The Curriculum Development SIG organised a range of staff development workshops, established 13 teacher advisory boards [Case Study 17], and produced a guide on the transition to higher education STEM study as part of wider Programme project led by the Midlands and East Anglia

Spoke. 184 delegates attended the 7 workshops that covered the cross-disciplinary issues of eAssessment, community engaged learning, addressing the needs of employers, and enhancing employability. The delegates were drawn from 54 HEIs and 21 external organisations, and the workshops were delivered through a collaborative model of academics working in partnership across institutions: the University of Exeter worked alongside the University of Bath: Imperial College London alongside Loughborough University; and, the University of the West of England worked alongside Brunel University.

66. The Public Engagement and Widening Participation SIG initiated a range of activities to share effective practice. A good practice guide bringing together effective Programme practice was produced along with a series of case studies[11] showcasing practices in engaging the public with disciplinary research in support of Research Councils UK's Pathways to Impact initiative. Professional development events were offered to the higher education sector including the 10 SuperLab Master Classes where representatives from the British Science Association and the NCCPE provided training in producing posters for communicating research through public engagement; the SIG also initiated the Aimhigher workshops discussed earlier.

67. Reaction towards the SIGs, their role and success within the Programme was mixed:

"The majority of Spoke Teams expressed the view that the Special Interest Groups had not made a major contribution to collaboration although some activities had been evaluated positively by those who had participated in them…In addition interviewees reported that some of the SIG-sponsored activities did not seem particularly relevant either to Spoke project team members or to Spoke staff. Sharing the management of the SIGs between Spokes was also not perceived as promoting additional meaningful collaboration between Spoke Teams." Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

However, some partners reported that they had provided opportunities for information sharing across the Programme which was also a key reason for their establishment:

"SIG meetings provided the opportunity for officers to share relevant activities from their regions and professional bodies and to agree on a programme of activity for the SIG to tackle a range of cross-disciplinary issues." Final Report, South West Spoke (2012)

[11] http://www.rcuk.ac.uk/media/brief/impactcase/pe/Pages/home.aspx

"SIGs were successful in helping Spoke staff to keep track of activity in other regions..." Final Report, London & South East Spoke (2012)

68. There are several instances of successful practices or approaches that were initially initiated by one partner being subsequently undertaken by another; this includes examples of practices being transferred between disciplines. For example, the IMA developed a Mathematics Large Outreach Kit (MLOCK) [Case Study 6] to enable departments of mathematical sciences to engage more effectively with careers fairs, science fairs and open days. 19 MLOCK kits have been distributed on a regional basis where they are shared in a manner similar to the RSC's SIAS initiative. Several Spokes have also further supported the roll-out of MLOCK by purchasing additional kits for use within their region.

69. The STEMBUG Gateway developed in the North West influenced and informed the development of two related projects: one in Wales and one in the London & South East Programme region. In the Solent region a website was established to provide a mechanism for SMEs to engage with the 3 Solent universities for interns, recruitment, curriculum involvement and small scale research or feasibility studies:

"14 engagements between HEIs and business occurred through employers using the website. These engagements took the form of more traditional activities such as skills development courses. The single point (face to face) brokerage service provided by the project was beyond the existing facility of the host and partner institutions' business engagement services…24 engagements between SMEs and HEIs occurred as a result of this more focused brokerage." [Project Report, Business & University Partnerships Portal, University of Southampton]

70. Collaboration across Programme partners also resulted in the creation of collections of good practice or briefing documents to influence policy. For example, one of the earliest outputs from the Programme was a good practice guide that brought together learning from the four pilot projects[12]. The Wales Spoke collaborated with other programme partners to produce an employability briefing guide, aimed at senior management teams in higher education institutions in relation to embedding employability within the curriculum[13].

71. Collaborative activities have also been established between Professional Body Partners. The RAEng is supporting an initiative led by the IoP to raise the number of specialist Physics teachers in schools by encouraging final year undergraduates in engineering to consider a career in physics teaching. A series of awareness raising events were held for undergraduates, including some Spokes, in the final year of the Programme.

"The IoP considers it is now working more closely with the RAEng and the RSC as a result of the Programme activities." Hollins, A Review of Selected Projects with a Focus on Impact and Sustainability (2013)

72. The Programme's approach to transferring effective practice between higher education institutions was not only through the provision of 'pump priming' funds to enable the implementation of ideas, but more particularly through facilitating and enabling access to other individuals with appropriate expertise who were able to share resources and experience to support the wider embedding of an activity within another institution:

[12] http://www.hestem.ac.uk/sites/default/files/j1877_a4_gpg_web.pdf

[13] http://www.wimcs.ac.uk/document_repository/Employability%20Skills%20Guide.pdf

"The support received from Sheffield University [Name Removed] was very helpful in terms of structuring the board and providing templates/sample documents. The meeting held at the IOP in February was also very useful, allowing me to learn from the experiences of others and put these findings into practice in my own institution." [Project Report, Industrial Advisory Boards, University of Leeds]

"It was invaluable to discuss the trial prior to its start with the resource developer who was extremely helpful and it allowed us to see how we could work this into our curriculum." [Academic Member of Staff, Chemistry C/PBL, University of Salford]

73. A further example of this approach was in relation to transferring effective practice in relation to the development of graduate skills within the mathematical sciences [Case Study 42]. While the collation of case studies can provide valuable exemplars for others, sometimes modest pump-priming funds are needed to enable the activities to be implemented elsewhere. A series of 17 case studies provided examples of effective approaches to developing graduate skills in a mathematical context, and these were further shared at a series of workshops. Three projects building upon these ideas were established which continue into 2012/13 including a new course at Lancaster University to enhance student communication skills and the use of progress files to encourage student reflection at Greenwich.

74. While the wider transfer and embedding of pilot project practices such as Context and Problem Based Learning (C/PBL), Integrated Sciences, and Applied Physics, which have all greatly benefitted from this approach will be discussed in Section 6, four national open calls were offered to the higher education STEM community to transfer and embed effective practice through collaboration, namely the 'Collaborative Projects Initiative', 'Menu of Activities', 'Practice Transfer Partnerships', and 'Practice Transfer Adopters', listed in order of implementation within the Programme.

The Collaborative Projects Initiative

75. In early winter 2009 the Collaborative Projects was launched with an open funding call for one-year projects. The remit was to transfer proven practice into, between, or within, higher education institutions; in effect, taking a successful activity, resource or approach that had been developed elsewhere, possibly in a different discipline, and enabling others to implement it within their institutions. The intent was to encourage and develop collaborations that were self-identified and self-led rather than brokered by the Programme itself. Twenty individual proposals, with an average value of around £10,000, were supported following a highly competitive selection process from a total of 78 applications.

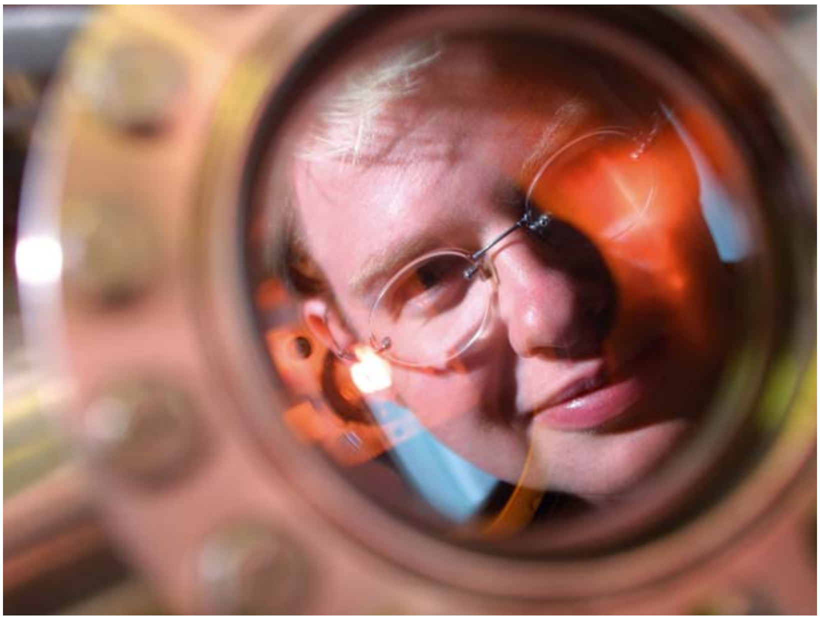
76. The successful projects almost exclusively aligned with two of the three activity strands of the programme, namely: widening participation by working with those currently within the school and further education sectors; and, higher education curriculum developments with an emphasis upon course delivery and design and student support, to enhance student knowledge, progression and skills. In particular, almost all of the projects were either focused around proven outreach activities, interventions, or approaches with local schools and colleges, the student transition to higher education study, and automated assessment using computer-based technologies.

77. As these projects were some of the earliest established within the Programme, they perhaps provide the greatest visible examples of both sustainability and legacy. In the majority of cases

activities are now continuing within the departments who participated, including instances where these have been extended or developed further; some practices were also subsequently transferred more widely to other institutions through the Programme. In the small number of cases where the activity has not continued outright in its exact form, it has informed wider practices and approaches within the institution. For example, at Lancaster University, a number of the sessions that were specifically developed for the regional Lancashire STEM Symposium have been adapted for use in school visits and events.

78. At the Universities of Liverpool, Loughborough and Newcastle the activities and approaches developed through the National HE STEM Programme have been directly adopted by other higher education institutions: Liverpool is currently working with the Universities of Derby and Exeter to help them embed the diagnostic tools for engineering students; Loughborough with the Universities of Birmingham, Bradford, Cumbria, Exeter, Salford, Staffordshire, and the West of England are embedding student led projects; and, Newcastle with the Universities of Bradford and Kingston to transfer a mathematics eAssessment system. The project at Newcastle University formed a cornerstone of a subsequent large-scale curriculum project focused upon computer-based assessment within the mathematical sciences led by the University of Leicester [Case Study 41], and in a further activity directly related to this initial project, Newcastle has made high quality diagnostic tests in mathematics nationally available in response to identified demand.

79. The mathematics busking project led by the University of Manchester subsequently offered a further national series of training events, and the use of undergraduate students as 'maths buskers' was formally extended to the University of Leeds. As a legacy of one of the collaborative projects (Transferring the Magic to STEM) (Case study 20) and in an initiative led by the project lead, Queen Mary, University of London secured significant financial support from Research Councils UK to establish a Centre for Public Engagement at the University.



80. At the Universities of York and Surrey, who both undertook complementary activities to address issues with the laboratory skills of new undergraduates within Chemistry, further development of the materials has continued with additional videos also being produced for use by year 2 and year 3 students (York), and by other departmental staff members not initially involved directly in the project (Surrey). This project also provides an example of collaborative activity brokered through the Programme. Given the similar nature of both proposed projects York and Surrey worked closely to ensure their work complemented, rather than duplicated, each other's efforts.

The Menu of Activities

81. The learning generated from implementation of the 20 collaborative projects impacted upon the subsequent approach of the Programme in building upon existing effective practices and interventions. A follow-up initiative provided a suite of proven activities, derived from the work

of the four disciplinary pilot projects, for which universities were able to receive both financial resource and access to expertise from Professional Body Partners to support their implementation:

"In this vein the evaluation team notes with approval the approach to the call issued by the HE STEM programme for proposals that build on proven intervention strategies – in effect building on the knowledge gained in the pilot projects and providing seed money to transfer good practice between institutions." Evaluation of HEFCE's Programme of Support for Strategically Important and Vulnerable Subjects, HEFCE (2011)

82. The objective of the Menu of Activities initiative was that if the universities found the activities complemented or added additional value to their existing work, then they would embed these within their core provision and continue to offer them into the future. A secondary objective was that as the approaches were based upon interventions that had previously demonstrated proven impact (following their evaluation as part of the pilot projects), the experience of implementing these in the described manner might also influence some of the wider practices within the 'adopting' department or faculty. A final objective was that as the outreach activities needed to be demonstrably targeted at traditionally underrepresented groups of learners (widening participation cohorts), the experience generated from working with other STEM initiatives and organisations or central university departments to achieve this would help embed a longer-term way of working within the sector that would enable continued targeting of hard to reach cohorts.

83. In total 65 projects successfully completed the Menu of Activities initiative. Of these projects, 51 were focused upon delivering outreach activities to local schools and colleges, 5 were context or problem based learning activities with undergraduate students, and 9 involved the provision of professional development opportunities to higher education staff and students. Given the dominant focus of the Menu of Activities initiative was upon enhancing higher education working with schools and colleges, these projects are discussed within Section 5.

Practice Transfer Partnerships

84. In mid-2011 the Programme established its Practice Transfer Partnerships (PTP) initiative which offered higher education institutions or other STEM organisations with effective, and in particular evidence based practice, the opportunity to further transfer and embed this within the higher education sector:

"The Engineering Council was aware that a range of other HEIs were interested in developing such degrees, but sometimes barriers to implementation were cited as the reason for not progressing to the design and delivery stage. The National HE STEM-funded Practice Transfer Partnership was seen as an important opportunity to fund a project that would draw on and transfer the range of experience, successful practice and differing models of delivery, enabling other HEIs to offer such degrees at Masters or Bachelors levels." [Engineering Council Representative, Engineering PTP]

85. Following an open call, supported by strategic targeting by members of the Programme team, areas of effective practice were identified, and partnerships in key activity areas (outreach and strategic regional working with schools and colleges; diversity; retention; careers; work-based learning; and, University Technical Colleges (UTCs)) established to add value to the Programme. To an extent, the

process involved bringing together or trying to merge proposals or potential partners with similar interests; this yielded mixed results:

"However it proved difficult to incorporate the aspirations of some of these partners into the main theme with one partner [Name Removed] subsequently withdrawing and the activity of others changing as the project progressed. This necessitated the renegotiation of agreements with those partners affected." [Engineering Council Representative, Engineering Gateways]

86. However, there is evidence that this worked effectively in the Partnerships where different, but complimentary activity strands could be incorporated into a common collaborative framework. Examples include the Diversity PTP led by the IoP which included strands, led by different Programme partners, on gender, disability, socio-economic status, and looked after young people, and the Careers PTP led by the University of Southampton:

"The overall approach was successful as each partner was working on a project that they owned and for which they had the professional knowledge and skills…It is evident that it is difficult to create partnerships from scratch. In this respect the project was very successful as the individuals from each HEI worked very well together and, in reality, over-delivered based upon what could have been expected from the time paid for." [Final Report, Careers PTP]

87. The Careers PTP undertook several strands of activity with a view to helping STEM departments better integrate careers focused activity into the student experience. This included understanding how to plan STEM careers learning, supporting staff to develop enhanced careers awareness, the development of a careers resource bank for staff, and engaging students with the career benefits of chartered status. Such work naturally included the development of a range of supporting resources and materials over the final year of the Programme, but there is already evidence that these have already utilised by higher education institutions:

"…two STEM departments have already integrated the Chartered Status resources as credit bearing assignments on their undergraduate degree course: Maths department at the University of Salford and the Physics Department at the University of Portsmouth." [Final Report, Careers PTP]

88. The Midlands and East Anglia Spoke led the Retention PTP bringing together effective practice from across both the Programme, and the wider higher education STEM sector to produce a series of eight briefing guides[14] for use by staff which contain both guidance and examples of effective practice.

Practice Transfer Adopters

89. Another, and perhaps the most innovative of all the Programme's approaches to disseminating its work, provided a focused opportunity for other universities who had not previously participated in a specific activity to directly 'adopt' the intervention for themselves. The Practice Transfer Adopters (PTA) scheme was deliberately designed to be an active form of dissemination, 'uptake', that would enable practices to be embedded within the sector. Financial support was provided to the 'adopting'

[14] http://www.hestem-mea.org.uk/projects/retention-practice-transfer-part/the-suite-of-transition-and-rete/

universities to adapt and embed the activity within their curriculum, and to enable the existing project leads to provide ongoing advice and guidance during the implementation process. This initiative alone has resulted in 84 examples of effective practice being transferred across the sector.

90. The adaption and embedding phase of the PTA scheme was formally scheduled to commence in January 2012, and so exploring the impact of the transferred interventions is difficult as they will have only become operational for the first time in 2012/13 and as such will not yet have had chance to evaluate outcomes. This is perhaps an area worthy of future study to explore both the effectiveness of this method of transferring practice and the impact that the adopted interventions have had within higher education institutions. Nevertheless, there are already examples that the PTA process of building new collaborations between individuals can be successful:

"The Newcastle team were welcoming and forthcoming with information at the initial planning meeting…and have been supportive ever since." [Project Report, PTA Adopter of Numbas CAA System, Kingston University]

91. The PTA initiative has also been able to transfer interventions on a disciplinary basis. The Universities of Lancaster has successfully implemented the first stage of the SYMBΩL project, which began at Loughborough University, with 5 interns working over the summer with academic members of staff on a second year mathematics module. At Exeter, the same project lead adopted both the SYMBΩL project and the Proactive Intervention for Students with Non Typical Mathematics Backgrounds project first developed at the University of Nottingham, and both have already resulted in a significant impact:

"The project has made a real difference to the students who were involved resulting in some really substantial improvements in Exam marks for mathematics and really positive feedback." [Academic Member of Staff, PTA Adopter Proactive Intervention for Students with Non Typical Mathematics Backgrounds, University of Exeter]

"The success of this project has resulted in a successful application to the HEA for funding to expand this model of students as 'co-creators' from Mathematics into other disciplines across the College. We now have a number of groups from medical imaging, physics and engineering all working on the 'co-creation' of student resources, they are working within our VLE, which was previously very much the preserve of staff. This project has been a really transformative project within the College, changing attitudes and ideas about involving students so directly as partners in learning." [Academic Member of Staff, PTA Adopter SYMBΩL, University of Exeter]

92. The Science Communication module at the University of Birmingham [Case Study 55], which has been delivered since 2010 as a 10 credit transferable skills module, and currently taken by over 350 students in 2012/13, demonstrates that the PTA scheme is also able to transfer effective practice between disciplines with two universities adopting it for engineering, design and technology, and computer science students:

"Science Communication was delivered as 'Professional and Research Themes' to all first year students in the School of Electronic Engineering and Computer Science (EECS) at QMUL in the 2012/13 academic year. The cohort size is 240 with degree programmes ranging from BEng Electronic Engineering to BSc Information Communication Technologies." [Project Report, PTA Adopter of Science Communication, Queen Mary University of London]

93. The **sigma** network sought to enhance practice across six existing mathematics support centres through the PTA scheme. At the University of Leeds the mathematics and statistics support service enhanced its statistics support provision by offering a new range of help services including specific drop-in sessions for any student, and one-to-one booked appointments for undergraduate final year projects, postgraduates and research students. Birmingham City University gained experience in providing a remote statistics advisory service using Elluminate based upon a model previously established by the Programme at Loughborough University. At the University of Bath the support staff gained experience to assist them in providing mathematics and statistics support for students from vocational backgrounds.

94. In addition to the PTA scheme developing a collaboration between the Adopter and the original project lead, the limited implementation time before the end of the Programme meant that a number of the implementation meetings had to take place as a group involving all Adopters. This has allowed interactions and collaborations to develop between the adopting institutions as well. For example, the three Adopters of the Developing a Community of Practice for STEM Outreach and WP Practitioners project (the Universities of Bradford, Hertfordshire and Loughborough) have, through the project adoption, created their own support network amongst each another, as well as developing links with a total of 16 new community organisations.

Establishing Collaborative Activity

95. There is overwhelming internal and external evidence that the National HE STEM Programme has undertaken all aspects of its activities in the collaborative manner first envisaged within its March 2009 proposal to the Funding Councils. In addition, there is evidence of its effectiveness in this area:

"In our online survey, project leads were mostly positive about the Programme's effectiveness at supporting collaboration and sharing of good practice across the HE STEM sector, with three-quarters giving high scores for effectiveness in this area." CFE, Summative Evaluation of the National HE STEM Programme (2013)

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96. While some collaborations were self-identified, others mutually developed through relationships established during the course of the Programme, while others were encouraged or brokered by the Programme Team. While collaboration has been extensive, this does not always mean it has been universally welcomed:

"Academic staff in the mathematics departments of the universities of Kent and Brighton had previously worked collaboratively on research activity. The L&SE Spoke co-funded a project with the IMA that enabled the same academic staff to work collaboratively on Higher Education Curriculum whilst allowing the students to undertake outreach work in local schools. However, project staff report that on this particular project 'we are collaborating but it is a sort of forced marriage'." Final Report, London & South East Spoke (2012)

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97. It is appropriate to conclude this section by considering perhaps the key reason for such extensive, and far reaching, collaboration being achieved across the Programme. This is down to the hard work, commitment and dedication of those who worked to establish and broker its activities:

"From our first engagement on the programme through the application process to approval we have found the HESTEM staff extremely helpful and supportive." Academic Member of Staff, Project Report

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"Without the seed money and support from HE STEM in the initial development stages it is unlikely that the Hydrographic Academy would exist, certainly not in its current form." Academic Member of Staff, Project Report

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"We've had excellent support, encouragement and networking opportunities." Academic Member of Staff, Project Report

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Section 5:
Widening Participation

Introduction

1. Widening Participation (WP) or Widening Access was a central and underpinning theme of the Programme's March 2009 proposal to the Funding Councils. While a core focus for the Programme was to increase participation within the STEM disciplines at university level, it sought to do so by working with traditionally under-represented groups of learner. This included those not currently well represented within higher education (those from lower income families, people with disabilities, looked after young people, and those who have studied vocational courses) and those not well represented within the STEM disciplines (certain ethnic and/or gender groups, and part-time learners).

2. The Programme adopted a broad approach to the meaning of widening participation in line with the definitions used by both HEFCE and HEFCW:

> **"We see widening participation as a broad expression that covers many aspects of participation in HE, including fair access and social mobility. We continue to emphasise - but with renewed focus – that addressing widening participation relates to the whole 'life-cycle' of a student in HE. This covers pre-entry, through admission, study support and successful completion at undergraduate level, to progress on to further study or employment." HEFCE (2013)[1]**

The approach included supporting and encouraging part-time learning within the STEM disciplines, defined to be a priority for HEFCW[2] in terms of widening access, and as such aligned closely with the Programme's higher level skills strand and its work to provide upskilling opportunities to those within the workforce without a prior university-level qualification.

3. Given the existence of a range of STEM organisations already working with schools and colleges to increase and widen participation prior to the start of the Programme, many of the Programme's activities to develop or enhance university relationships with schools and colleges were undertaken collaboratively, or following consultation with, these organisations; details of the collaborations that developed have been discussed within Section 4. Additionally, the Programme recognised that many university-led activities with schools and colleges may be undertaken by central outreach or widening participation units, and as such encouraging STEM members of staff to work with their colleagues in central teams, particularly in relation to targeting widening participation cohorts was also a priority.

[1] http://www.hefce.ac.uk/whatwedo/wp/policy/

[2] http://www.hefcw.ac.uk/policy_areas/widening_access/widening_access.aspx

4. Recognising the broad definition of 'widening participation' taken by the Programme, this section focuses upon the work of the Programme to encourage and support underrepresented groups of learners to enter higher education and engage in STEM study, and to enable universities to work more effectively with the school and college sectors. Supporting students once they commence higher education and helping them to progress successfully to the workplace are also important WP priorities, as are providing opportunities for part-time learning for those currently in the workplace. Given these areas align with the Programme's curriculum and higher level skills strands, they are also discussed extensively within Sections 6 and 7 of this report.

5. The particular emphasis of this section may strongly reflect the Programme's widening participation work with schools and colleges more than its other areas; this is perhaps to be expected. As discussed within Section 2, perhaps the dominant national policy driver for the work of the Programme at its outset was higher level skills. However, with the changed higher education environment within England and Wales, particularly with the introduction of the Access and Fee Plan Agreements and the need for universities to document their efforts to widen access and participation, working with schools and colleges took on a renewed importance. For example, within Table 8.2 which highlights references to 'STEM', and variations thereof, in the 2012/13 and 2013/14 Access and Fee Plan Agreements, many of the activities relate to working directly with schools via what are commonly termed outreach activities. The other area most commonly referenced is mathematics support.

Embedding Effective Outreach Interventions

6. The four disciplinary pilot projects not only developed a series of interventions to enable higher education institutions to better engage with those in the school and college sectors, but also valuable learning and understanding to increase the efficiency of effectiveness of university led approaches. In preparing their work for wider transfer and embedding, each Professional Body identified a series of these activities that they would continue into the Programme. While each pilot project rationalised the activities it would undertake to those related to higher education, further opportunities arose for the more schools focused work to be rolled out nationally in collaboration with other STEM organisations.

7. In 2009 the Department for Education awarded the IoP, in partnership with the Science Learning Centres, a contract to build upon the success of their pilot project through the establishment of the Stimulating Physics Network[3]. The Stimulating Physics Network continues to offer a range of support for over 350 secondary schools in England, and has contributed to the IoP providing around 4,000 teacher CPD days each year in the English maintained sector. As the Network provides an ongoing mechanism for the embedding of the schools-focused activities from the Stimulating Physics Programme, much of the Institute's pilot project work was rolled out into schools in this manner.

[3] http://www.stimulatingphysics.org

8. The More Maths Grads project formally continued its activities until January 2010 which meant that it was able to package its resources and materials into 'boxes' before it completed. In the early stages of the Programme, it was therefore able to focus its activities upon encouraging higher education institutions to utilise the developed resources with their local schools; this was achieved through awareness raising and demonstration workshops within eight universities distributed across the Spoke regions. Such an approach meant the dissemination activities were able to align with a further project at the University of Manchester that recruited, through the STEMNET Ambassadors Scheme, undergraduates from the School of Mathematics to work with local schools. Over 40 undergraduates received training, and 16 schools participated in the subsequent activities that were undertaken by the Ambassadors:

"The links made with local schools and colleges have been valuable to the School of Maths. The contacts have been added to our mailing lists and some of the schools have started attending our other events. A key success of the project has been getting new schools involved in our other activities …The ambassadors who were involved have already been contacted about various school liaison events for the coming year and many have signed up to be involved…We have several events for teachers planned…" [Project Report, Opening the Box, University of Manchester]

9. The national roll-out of Spectroscopy in a Suitcase [Case Study 7], discussed first in Section 4, was extended to nineteen higher education institutions, and as a consequence 24,491 students were able to participate in one of the 520 events held. This greatly exceeds the original target of 5,000 students, and requests from schools for SIAS activities continue to outstrip the available capacity.

10. There is evidence of the impact of the SIAS initiative in enhancing the skills development of the postgraduate and undergraduate ambassadors who take the spectroscopic equipment into schools, including anecdotal evidence that some are considering a career in teaching and education outreach as a result of their participation. In some regions, higher education institutions have shared the equipment, and this too has proved effective:

"Postgraduate students who have been involved in the project have gained very valuable experience through working with schools. The challenge of sharing the equipment has worked well…" [Project Report, Spectroscopy in a Suitcase, University of Liverpool]

11. In addition to the ambassadors developing their own skills, they have also been able to support and advise school and college students, representing both their institutions and their discipline:

"Apart from the obvious of a greater insight into the workings of spectroscopy, the students gained a huge insight into how life is at university, they were able to ask many questions of the demonstrators and received well informed answers" School Teacher

There is evidence that this delivery approach is generating new relationships with higher education institutions. For example, at University College London [Case Study 8], approximately 10% of applicants are referencing participating in a spectroscopy workshop within their personal statements. Additionally, five schools without prior history (in the last five years) of applying to study chemistry at UCL, but who have participated in the scheme in the last 12 months, have had students submit applications to study Chemistry at UCL for 2013/14 entry.

12. All institutions participating in the SIAS scheme have now integrated it into their outreach programmes, and as such its continuation is assured. Further, the RSC has committed to supporting the activity and maintaining the national community that has been developed, as well as exploring mechanisms for its further expansion. This includes the development of new spectroscopic techniques and expanding the age range for SIAS events, and will build upon work undertaken at the University of Bath which developed resources that were used to illustrate spectroscopy in a broader range of areas.

"The Project will continue in Manchester due to the successful negotiation of [Name Removed] with both RSC and University of Manchester Widening Participation & Student Recruitment Office for funding. Transfer of practise has already occurred, in that we have had meetings with colleagues from Liverpool…and all documentation has been provided to University of Liverpool and Liverpool John Moores colleagues, with an open offer of help should it be needed." [Project Report, Spectroscopy in a Suitcase, University of Manchester]

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13. As discussed in Section 4, the SIAS approach has transferred to mathematics with the development of the Mathematics Large Outreach Kits (MLOCK) which are now based within 19 higher education institutions. While many of the kits were only finalised and made widely available to higher education institutions shortly before the end of the Programme, initial feedback has been positive indicating they will be a highly valued and well used resource:

"The counted footfall for the tent was 15,000 over the two days, and the Coventry stand was buzzing throughout. It certainly felt like we interacted with a significant fraction of the total footfall.... we borrowed the harmonograph and this went down a storm with all ages… [Academic Member of Staff, MLOCK Kit, Coventry University]

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14. Higher education institutions have also adapted the SIAS model to physics. For example, the Luggage Lab project at the University of Hertfordshire built upon the teacher support element of the Stimulating Physics project by developing a set of self-contained and portable physics experiments for use in schools-linked outreach. A collaboration with the Science Learning Centre East of England enabled these to be made available to schools. At the University of Bristol the HiSPARC project, which built upon a similar, and successful 10 year-old initiative in the Netherlands, enabled Key Stage 3 and 4 students from 7 schools to undertake real research on the cosmic rays that bombard the earth from outer space. The sustainability model involves schools making a financial contribution towards the cost of participation, and the detectors are currently installed at the University of Bristol.

"The key aim for this project was to launch HiSPARC in the South-West. We aimed for 2 schools within a 1-mile radius of the university with many further installations possible. We have been very successful…In total we will probably have 10 schools joining early on next year. There is further interest from Hereford, Birmingham and Cornwall. We are very happy with this and think that it is a big success, especially given that the schools need to contribute financially to the project." [Project Report, HiSPARC, University of Bristol]

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15. At the University of Salford, Meet the Scientist developed desktop demonstrations of non-carbon based generation, storage and utilisation of energy. The demonstrations were subsequently used at a series of events at Salford University and the Manchester Museum of Science and Industry where over 1,500 people interacted with the displays. The University of Salford also implemented, through the Practice Transfer Adoption initiative, Student Led Projects from Loughborough University; this approach helped enhance the development and sustainability of the Meet the Scientist activity:

"Further development of the demonstration facilities are being planned as part of student led projects at Salford. This includes a project led by the student physics society at Salford who are embarking on student led outreach activities in local schools and which will utilise the facilities above as well as develop further related facilities. Future staff led activities are also planned replicating similar events…at future dates and other venues, in particular at the Manchester Science Festival in October 2012 and further stand alone events in 2013 both in schools and at MOSI [Museum of Science and Industry]." [Project Report, Meet the Scientist, University of Salford]

16. The RAEng established five large-scale outreach projects to embed the learning from the London Engineering Project into the Programme regions [Case Study 2]. Each region adopted a differing approach to the activities undertaken, and this diversity was informed by the local knowledge of the Programme's Spokes who supported the development, implementation and delivery of the activities. A common theme for all projects was working with existing STEM organisations on a regional basis.

17. The Menu of Activities initiative, first discussed in Section 4, provided a focused and Programme-wide approach to embedding effective practice in relation to working with schools and colleges developed through the four pilot projects. Eleven outreach activities were offered, and there were 51 instances of universities successfully undertaking these. By analysing the individual case studies that were produced, it is possible to determine that around 420 schools or colleges participated in the outreach activities and that approximately 8,400 school and college age students were involved, although not all case studies provided this information. Around 175 teachers have also participated in, or supported, the activities undertaken.

18. The case studies provided by 39 of these 51 outreach projects all provide either evidence of how the activities have influenced or informed institutional practices, or an explicit intent to continue the activities in some form in future academic years. Not all activities will continue in their current format however; some have been modified to align with, or complement, the range of institutional provision available. For example, several higher education institutions now intend to undertake these activities, with others, during the annual National Science and Engineering Week as this is an occasion where schools and colleges are actively seeking to participate in STEM activities and have timetabled 'space' available to engage with universities. In other instances, the activities have been merged with existing offerings to enhance the overall provision, or have been modified to complement the disciplinary areas of expertise of the department or faculty.

19. A further feature of some of the modifications is providing sustained opportunities for student engagement with STEM activity which is known to be important for continuing to raise student aspirations and interest. For example at the University of Cambridge a 16 week science club was run in local schools that engaged over 215 students and culminated in the Year 9 Chemistry Day; another unique feature of this implementation was that it also provided professional development opportunities for teachers:

"Experienced teacher mentors had added comments in the end of term report about the excellent contributions all of the new teachers had made to STEM club activities. All of them also said they would incorporate the new ideas into their existing resources and would be more inclined to carry on with such clubs in the future. Four teachers said that they had learned some new chemistry ideas as a result of attending the Y9 day and would access 'the wiki' in the future. Surveys of wiki usages indicates that 10/18 of the experienced teachers have visited the wiki." [Project Report, Chemistry Outreach Package, University of Cambridge]

20. Several other universities implemented the activities as sustained interventions rather than 'one off' events, and a key feature here was the use of staff and student ambassadors to provide pre- and post- activities to the main event; this too is an approach that builds upon pilot project practices. For example, at Glyndŵr University ambassadors supported the development of the solar cars within schools before the campus based day, and at Leeds Metropolitan University, technical expertise was provided to schools to assist with the development of their final videos for Planet SciCast. Where such approaches did not occur, several projects have indicated they intend to implement such an approach in the future, for example the Ashfield Music Festival at Keele University.

21. In addition to activity continuation, there is also evidence of these projects exerting a wider influence upon the adopting department. For example, Bangor University has combined several of the workshops undertaken to produce an activity designed to enable students to achieve a British Science Association CREST Bronze award; this has already been successfully undertaken by 50 pupils. In addition, Bangor has participated in the SIAS initiative which presented an opportunity to combine the two activities:

"In response to the high demand for places on the Year 9 Chemistry Day course the team are developing the project so that it can additionally be run in schools as part of the Spectroscopy in a Suitcase initiative." [Project Report, Chemistry Outreach Package, Bangor University]

22. At Keele University the existing undergraduate STEM mentoring scheme has been extended to include mathematics, and at Brunel University, who adopted the Hands on Maths Workshops, the activities have influenced a wider student support programme:

"…these activities have widened our understanding of student transition and these lessons will inform future teaching and support of first-year and foundation students… Furthermore, we will use these activities within our current maths and statistics teaching and support programme, particularly for induction and promotional events for first-year and foundation students." [Project Report, Hands on Maths Workshops, Brunel University]

23. The Menu of Activities initiative has also helped develop relationships between universities where there was no prior record of collaboration taking place:

"Despite the close proximity between the two Universities, no previous collaborative activities had been undertaken within STEM Outreach projects…As a result of this activity… The Solar Car Challenge is running for a second time in collaboration between the two universities and a twilight session is booked…" [Project Report, Solar Car Challenge, Canterbury Christ Church University]

At the University of Wales Newport, who delivered a Mathematics at Work Day, collaboration will continue with Careers Wales Gwent, but the activity also provided an opportunity to engage with local employers:

"The University, working with Careers Wales Gwent, has developed closer links with local employers and will now embed work-based activities in the undergraduate ITT STEM curriculum. The perceived success of the Maths at Work day will now influence future practice in a number of areas. These include continued working with Careers Wales Gwent to support other STEM/curriculum enrichment projects such as an introduction of science, ICT and D&T work days. We will now embed an annual Maths at Work Day into the curriculum, which, it is anticipated, will provide an opportunity for local employers to engage more readily in the learning process and enable student teachers to develop employability skills and prepare effectively for professional practice." [Project Report, Maths at Work Day, University of Wales Newport]

24. In addition to expected outcomes, the Menu of Activities initiative has also provided some unexpected ones. For example, at Swansea University one of the Chemistry Outreach Package activities has now been adopted as a practical activity for first year students, and at Bangor University the process of developing a timeline for delivering an outreach activity, which was required as part of the expression of interest submission to the National HE STEM Programme, has now been implemented for other activities.

More Effective Targeting of Hard to Reach Groups

25. Throughout the outreach focused Menu of Activities projects, there is clear evidence that project leads have sought to ensure these are appropriately targeted at widening participation cohorts. While it is impossible to say, on the basis of the evidence provided, that such a targeting approach was implemented solely as a result of undertaking this National HE STEM Programme activity, it demonstrates there is significant evidence of good practice and that the targeting of widening participation cohorts is taken seriously by the higher education sector. The examples provided also show that often, targeting is undertaken in a collaborative manner either with central university units, or external STEM organisations and initiatives.

26. Many universities reported that the targeting of schools and colleges for their activities was undertaken by centralised widening participation units or by faculty members of staff with responsibility for outreach or access, using widely accepted indicators of widening participation status. Other approaches observed were the targeting of 'Communities First Schools', which is one of the Welsh Assembly Government's targets for widening participation; this targeting mechanism was widely used for activities undertaken in Wales. A related approach was observed for a

number of activities within England whereby 'Aimhigher schools' were particularly targeted; for the activities at Coventry University widening participation schools were identified in conjunction with the Local Education Authority.

27. A number of Menu of Activities outreach projects indicated particularly innovative approaches to targeting schools had been adopted by their universities. For example, at Keele University there exists the 'Keelelink programme' whereby joining schools and colleges are ranked for widening participation status using a series of indicators; some of the University's activities are then only available to schools or colleges with a high widening participation ranking, or these schools are given priority when booking events. The University of Exeter maintains an 'aspirational schools' list which contains details of schools who perform below the national average for UCAS tariff points per student and who are in the bottom 40% of schools nationally. When the Chemistry Outreach activities were then undertaken in Exeter, these schools were then asked to put forward students who met the well established Aimhigher criteria, indicating a clear intent to target widening participation students directly. Access and Community Engagement at the University of Leeds classifies schools engaging in outreach activities by the percentage of students from the bottom 13,000 super output areas in the country; HEFCE classifies these as 'disadvantaged learners'. This approach enables schools to be placed into bands according to their percentage of students from the lowest 13,000 super output areas, and as a consequence allows schools with the highest percentages of such learners to be targeted.

28. Further, a number of project leads also sought to 'verify' the widening participation status of those students who participated in the activities. The University of Bath for example highlighted explicitly, in a letter to schools, what was meant by the phrase 'students from disadvantaged backgrounds' and asked that such students be prioritised for the activities. At Liverpool John Moores University, during the activity day students were asked to indicate if family members had previously studied at university.

29. In addition to collaboration with centralised institutional units, there are a number examples of collaboration with other STEM organisations and initiatives to enable the effective targeting of widening participation cohorts. At the University of Liverpool, Maestro Services Ltd, formerly the Greater Merseyside and Cheshire & Warrington SETPOINT, was engaged to assist with the organisation of the activity. At the Universities of Sheffield and York activities were undertaken collaboratively with Business and Education South Yorkshire and NYBEP (the STEMPOINT for York and North Yorkshire) respectively who provided organisational expertise and enabled the targeting of appropriate schools; similarly Canterbury Christchurch University worked with Kent and Medway STEM which holds the STEMNET contract for Kent and Medway. The University of Durham targeted schools on the basis of those who had previously engaged with provision offered by the North East Science Learning Centre. The University of Wolverhampton has, for many years, facilitated a STEM focus group to bring together STEM practitioners from across the University, local schools and colleges, and the regional STEMNET provider; the activities undertaken were delivered through this group and targeted on the basis of this collective expertise.

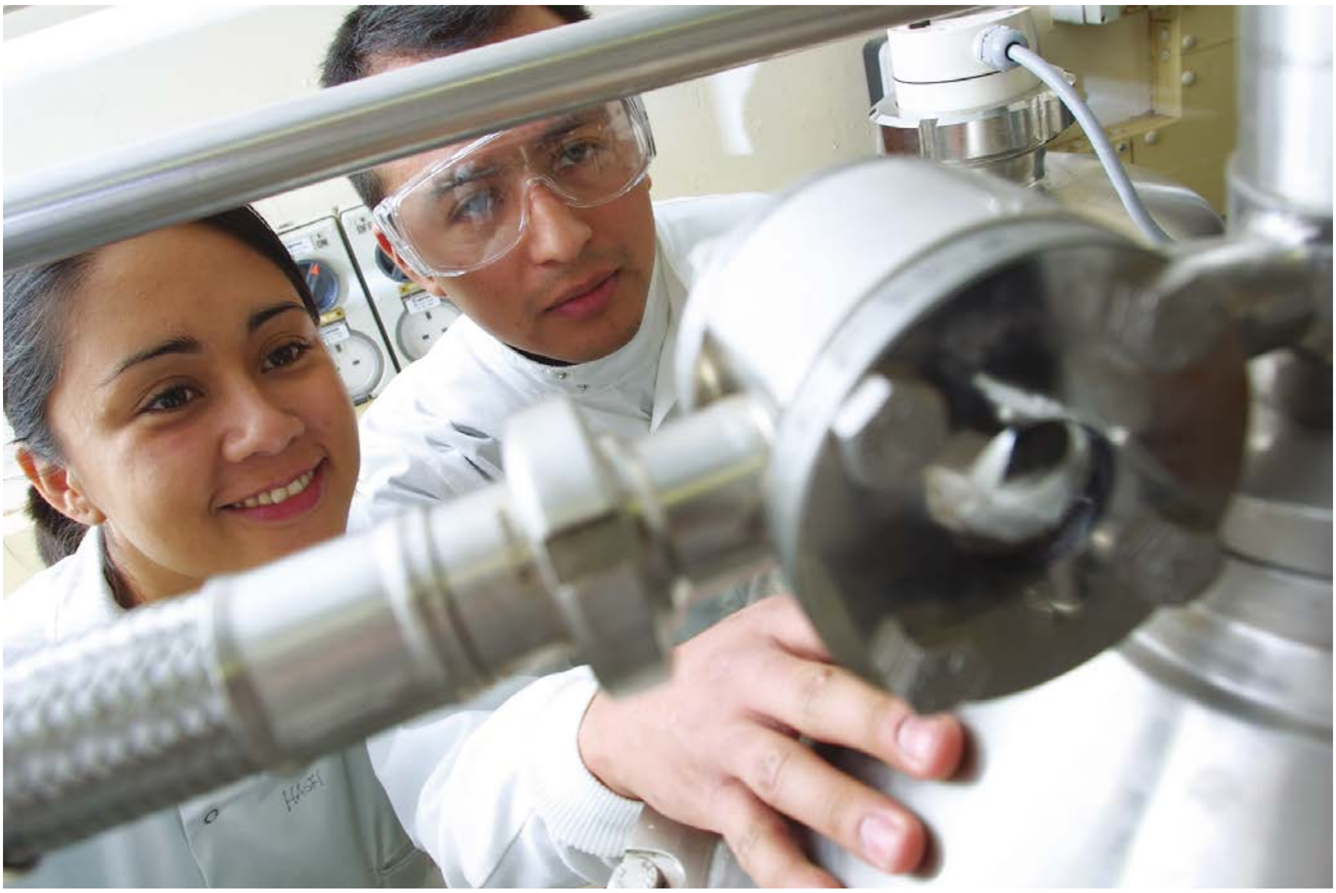
30. Through activities led by the Programme's Spoke partners, there were two significant projects initiated that worked with identified widening participation cohorts: Looked after Young People; and Generating Genius which worked with Afro-Caribbean boys. The RAEng also initiated a number of university led projects focused upon encouraging girls and young women to study engineering and STEM subjects as the proportion of female applicants to engineering and technology has remained one of the lowest of all disciplines at 12% for each of the last nine years; this was in addition to the five regional projects established in conjunction with the Programme's spokes which also

incorporated a targeted focus in this area. In Wales, the Spoke also established Discover Science Saturday Clubs for Girls at the University of Glyndŵr and Bangor [Case Study 4].

31. Choices Together first started as a joint project between the Universities of Sunderland, Newcastle and Northumbria, working with looked after young people on higher level skills and concepts to introduce them to higher education and encourage them to consider it as a progression route. Through the Programme the partnership agreed to change the basis of their work by using STEM topics and activities throughout the year. As none of the deliverers had STEM background its inclusion required advice from STEM departments and those delivering outreach; the result was the development of a new programme, 75% of which was STEM:

"It has been very clear from evaluations that the participants have thoroughly enjoyed the experience and in comparison to other years have found the hands on STEM based activities more enjoyable and motivational. It's also fair to say that most staff involved were pretty nervous about the introduction of STEM to this programme. But we have been very surprised at the amount of interest in the STEM activities and how well it has worked with the particular group of young people, including how easy it actually was to subtly introduce STEM to individual events without making it the sole focus of the programme." [Project Report, Looked After Young People, Northumbria University]

32. In addition to the modification of the existing Choices Together programme, its learning was transferred more widely to other Yorkshire universities who adopted components of the approach to align with, and enhance, their existing work. At the University of Huddersfield implementation



was led by the Department of Chemistry and Biological Sciences and targeted pupils in the final year of primary school with the aim of preparing them for the transition into secondary education.

"…because there's quite a skill base to build up when you're working with this sort of group of children, so yes, they will benefit, and we will be carrying on working in this area." [Project Report, Looked after Young People, University of Huddersfield]

33. The University of Leeds and Leeds Metropolitan University added a STEM focus to their homework clubs for looked after young people and trained students from their STEM departments to support the work of these clubs, while Sheffield Hallam University and the University of Sheffield worked with a group of looked after young people in Sheffield and Barnsley in conjunction with the local education authorities.

34. Generating Genius is a charity which supports high-achieving students from disadvantaged communities to develop the skills needed to secure places at high ranking universities. Generating Genius worked with Queen Mary University of London to deliver a series of development workshops for 20 Afro-Caribbean boys to support them through the UCAS admissions process to read STEM subjects at University. All 20 students secured places to study at Russell Group universities, and Google, with a £60,000 donation, is currently supporting a doubling of participants, the creation of hubs within a number of London schools, and providing engineers to mentor those now participating in the initiative.

35. At a policy level, the Programme's work with Generating Genius has attracted attention as a result of the learning it has generated with the Mayor's Office (London) requesting the Programme's participation in initiatives to improve access to the STEM disciplines amongst widening participation cohorts:

"As such I welcome the work that you do to raise the aspirations of black boys, working in partnership with other organisations. The department is interested in hearing more about your work and the evidence you have gather about what influences young boys' choices."
The RT Hon David Willetts, MP

36. To disseminate the learning that emerged from the work with Generating Genius, six workshops across England and Wales and a dedicated session at the Programme's national conference in September 2012 were held. Approximately 230 delegates from across the higher education sector ranging from academics to central outreach and recruitment services, attended the workshops, and were supported by the development of a good practice guide[4]. Two universities, Southampton and Queen Mary have committed to continuing to work with Generating Genius in their 2013/14 Access Agreements (see Table 8.1).

37. With support from the RAEng, Blackburn College University Centre developed an 'Introduction to Engineering' module aimed at potential female learners from black and ethnic minority (BME) groups to make them aware of the career opportunities available following the study of engineering at university. A targeted marketing campaign, the development of a mentoring system for this group of learners with local engineering companies, and staff training were also developed and implemented. Although the College has not yet enrolled any BME students, there has been an increase in interest in engineering courses from females from this background.

[4] http://www.hestem.ac.uk/sites/default/files/gengen_good_practice_guide_for_hestem.pdf

"Through this project, the college has built a sustainable model to engage and support BME females in engineering subjects. The college will continue its recruitment work and will extend this to encompass all females within the local community. We are currently engaging with the MentorSET initiative to see how we can become part of this and how it complements the output from this project. All of the activities and outputs from this project have been embedded into the college's normal practices..." [Project Report, Model for Engaging Women Within BME Populations, Blackburn College University Centre]

38. At the University of Greenwich, a partnership was developed within the civil engineering and construction sector to promote the study of civil engineering related courses amongst female students. The project worked closely with Atkins Global, and as a consequence secured funding to provide bursaries to support the highest achieving female students who would consider civil engineering as their future career:

"This project secured 10 x £2,000 bursaries per year as part of its activities...From the next academic year, a specific number of female students will directly benefit from these bursaries." [Project Report, Engaging Employers and Schools to Promote Civil Engineering Courses Among Female Students, University of Greenwich]

Professional Development: Gender and Diversity

39. Within the Menu of Activities, four projects provided higher education institutions with access to training in gender and diversity awareness, led by the UKRC, and enhancing university-led outreach practices. Nine universities were successful in securing support for these workshops, although the majority were implemented in a manner that allowed other regional universities and stakeholders to participate. Of these nine, seven provided evidence within their final case studies of how the training sessions subsequently influenced or informed institutional practices.

40. The University of Liverpool ran both the Gender Awareness and Doing Outreach workshops. The Gender Awareness Training was undertaken in response to an identified difficulty from the Physics Outreach Group of attracting girls and young women to participate in outreach events, particularly those from all girls' schools. In response the University had encouraged female undergraduates and postgraduates to plan some events, but wanted to ensure they were appropriately supported by members of staff. Since undertaking the training, the Physics Department has initiated a range of activities to encourage participation in physics from female students including a Women in Physics event for AS-level students, Women in Physics 2012 events and involvement in all-girls science events in schools:

"At a simple level we have more HE staff across several Schools and Institutes in Liverpool who are better prepared to integrate good practice in encouraging girls, (and potentially those from a non-traditional background) into science both in terms of admissions and outreach. Many of these practices will actually improve events in general. Perhaps most importantly, as many of the attendees were currently lecturing staff in the physical sciences at universities they may integrate such good practice into their lecturing and teaching (this was discussed by attendees as their aim). At the very least awareness of problems potentially faced has significantly increased." [Project Report, Gender Awareness & Doing Outreach Training, University of Liverpool]

41. At both Coventry and Southampton Solent Universities, who participated in the Gender Awareness and Diversity training, activities have been identified to incorporate the learning within the core practices of the institutions. For example, Southampton Solent has already undertaken a range of (collaborative) activities with the aim of increasing participation amongst female students; a number of which have targeted a female only cohort. At Coventry University, the impact has been more at an individual level, with staff identifying how they will respond to the issues discussed, and good practice identified during the workshop session.

42. The Gender and Diversity training provided to be popular, and as such it was offered more widely, either through a series of five regional events [Case Study 10] particularly focused upon careers professionals from higher education, further education, and adult services, or as more bespoke training offered to individual universities to support their projects, for example as happened at Blackburn College University Centre where 19 staff attended a one-day event.

"One of the most significant changes has been the changing of attitudes and understanding of the admissions team, school liaison and lecturing staff as they have become aware of the cultural difficulties and how to overcome and discuss these with potential students." [Project Report Model for Engaging Women Within BME Populations, Blackburn College University Centre]

"We run a girls only STEM event held here at the university where 8 of our local secondary schools brought along a group of girls to experience taster sessions of SET courses and speak to some of our female students and academics" [Delegate, Gender Equality in STEM Workshops – post workshop follow-up]

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43. Through the Careers Practice Transfer Partnership, the Quick CAT Staff and Student Culture Surveys[5] were developed with the aim of helping university STEM departments improve their understanding of how gender issues impact on the working and learning environments of staff and students and what, if any, improvements may be needed to ensure equality of opportunity. The surveys provide a useful tool for work relating to the Research Excellence Framework (REF) and providing a baseline for initiating engagement towards recognition and award schemes including the Athena SWAN Award. Although the Quick CAT tool only became available towards the end of the Programme, there exists evidence it is already being used by universities in support of the Athena SWAN charter:

"We surveyed staff and PhD students in April 2012 using QuickCAT to get a better picture of the School's culture… and then by repeating the QuickCAT survey in the summer of 2014, assessing progress against our 2012 benchmark." Extract from University of Edinburgh School of Biological Sciences Application for Renewal of the Athena SWAN Silver Department Award[6]

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44. A number of universities have engaged with the Programme's work on gender and diversity, and it is interesting to note that over the period of operation of the Programme 27 universities applied to join the Athena SWAN charter[7], and a further three applied post Programme. While this cannot be directly attributed to the work of the Programme, as it is recognised there are other factors that may have driven participation, three universities who hosted workshops (the Universities of

[5] http://www.theukrc.org/for-organisations/he-stem-culture-surveys

[6] http://www.docs.csg.ed.ac.uk/EqualityDiversity/Biological_Sciences.pdf

[7] http://www.athenaswan.org.uk/members_list

Birmingham, Coventry and Northampton) have joined the Charter, and the lead for one institution (Coventry) is the individual who requested support from the Programme to implement the training.

45. A focus upon gender and diversity has underpinned aspects of the Programme's higher level skills work. At University College London the SET for Leadership project explored the differences between male and female engineering graduates from their undergraduate studies to the workplace. The project engaged key employers in an industry survey on the recruitment process for graduates, through one to one interviews and round-table discussions with academics and employers and human resources professionals with the aim of bringing modern leadership and team models into the higher education environment to increase the confidence of undergraduates to meet employers' needs and expectations more appropriately.

46. The findings from the scoping work were used to develop work-related leadership projects with employers using resources, videos, group activities, discussion topics and coursework for undergraduates. Two industry open days at Arup and Microsoft saw over 200 female students attend, and the workshops held to test the developed materials identified several other universities who wished to either incorporate, or develop them further:

"Through the pilot we hope to run with UCL and other universities, we aim to explore take up of the resources and improve them. Loughborough will definitely be using them. Cardiff, Kingston and the Open University also expressed intent to take them further forward. UCL will hold a leadership in engineering forum to explore progress and developments."
[Academic Member of Staff, SET for Leadership, University College London]

47. Similarly the University of Greenwich observed that while mathematics graduates are viewed by employers as possessing well developed technical skills, they are often weaker on communication and teamwork. In particular, they noted that some students from BME communities or non-traditional backgrounds, often have low expectations, low aspirations and lack self-confidence, and as such do not always make effective applications when they are job-hunting. A project was initiated with the Adab Trust (an organisation dedicated to increasing graduate level employment outcomes for students from Black, Asian and Minority Ethnic communities) that addressed this issue through masterclasses and workshops for current students and recent graduates, and has helped enhance their awareness of their employability, built confidence, and improved their career opportunities.

48. The project recognised it was important for expertise to become embedded within the department, and so it also focused upon developing the skills, knowledge and confidence of teaching staff so that support could continue to be provided after the project concluded through professional development activities and workshops:

"At the start of this project the department's academic staff lacked the expertise to run the sort of sessions that the Adab Trust delivered for our students. As a result of this project, staff are now in a position to run CV clinics, train students to prepare for competency based interviews, and provide guidance on the application process. In addition, working with the Adab trust has enabled us to make relationships with several key local employers. These employers have all offered to work with us in the future… Lessons learned from this project are influencing the curriculum design in our current review and redesign of undergraduate maths programmes…" [Project Report, Making Maths Graduates More Employable: An Enhanced Role for Tutors, University of Greenwich]

Professional Development: Ambassadors, Public Engagement and Outreach

49. Encouraging members of staff, postgraduate and undergraduate students to become STEM Ambassadors formed the core basis of the Programme's work with STEMNET. STEMNET Ambassadors had key roles within the RAEng's regional outreach projects, and the Children Challenging Industry project (Case Study 15) in the north west involved six universities, ten secondary schools, 44 teachers from 40 feeder primary schools and 35 STEM Ambassadors in providing curriculum enrichment opportunities relating to the chemical industry. In total over 1800 school children have benefitted from this provision.

50. While working with STEMNET to support the recruitment and utilisation of ambassadors was a core feature of the Programme's work in this area, other models of utilising student ambassadors were developed and implemented. Activities in this area were a priority for many higher education institutions as they recognised they could not only utilise ambassadors to support their work with schools and colleges, but also that the ambassadors themselves would develop wider skills. Student ambassadors were crucial in enabling successful delivery of the Spectroscopy in a Suitcase initiative, and trained ambassadors were employed in the Maths Busking projects at the Universities of Manchester and Leeds. Aberystwyth University now extensively uses students within its activities, including as physics buskers:

"In general there has been added value to the University's existing Outreach programme, in particular, an increased pool of outreach ambassadors: more Physics Buskers trained through STEMNET; more PhysChic young women, who are... fund-raising and coming up with innovative ideas; more science and maths outreach students on the mainstream 'Student Leader' programme…The manager of the Centre is convinced that the project has raised the profile of outreach in the maths and science departments and has also resulted in the increased number of individual interactive stands at the University's Science and Engineering Week festival..." Hollins, A Review of Selected Projects with a Focus on Impact and Sustainability (2013)

51. Given the extent of engagement with student ambassadors at Aberystwyth University it is perhaps not surprising that Aberystwyth were one of the five universities (also the Universities of Bangor, Cardiff, East London and Loughborough) who participated in a STEM Ambassador training sessions to support one of the Practice Transfer Partnerships. Between 60 and 70 participants attended the training, and departmental staff also had the opportunity to experience the training being delivered to encourage continuity. The project was completed with the production of a resource pact to enable higher education institutions to train their own student ambassadors.

52. At the University of Central London an innovative approach was offered whereby the Extending Your Outreach training event from the Menu of Activities was offered to 20 first and second year postgraduate chemistry students to equip them with the skills to plan and deliver their own outreach activities. The participating students were not only able to accrue 'training points' for attending the workshop, which contribute towards the approximately 210 hours of development activities they are advised to undertake by the UK Research Councils during the duration of their studies, but training points are also awarded for the development and delivery of outreach activities:

"Many events coordinated by the students who attended this training event are now in the early or late planning stages. These include several events for National Science and Engineering week which include 4 new workshops designed by people who attended this training event." [Project Report, Extending Your Outreach, University College London]

53. The Stand out STEM Students project at the University of Central Lancashire set out to establish an accredited experiential elective module in the development and delivery of STEM outreach, that would give undergraduates the opportunity to develop employability skills through involvement in live STEM outreach and engagement initiatives. While the development of an accredited module proved not to be possible due to difficulties finding an appropriate 'location' for it within the University structure, semi-structured opportunities were offered to students and the intent is to work towards the vision of the accredited module in 2012/13 by aligning it with UCLan Advantage, the University's recently launched student experience package, in a manner appropriate for each academic school.

The activities produced…have led to an increased awareness of opportunities for students to engage with, and lead, outreach activity, and this is being reflected in the following: Increased numbers of students signed up as ambassadors; establishment of the Robot Club, students involved actively seeking new opportunities and external funding; outreach opportunity [sic] being considered as a 'work placement' offering through the UCLan Advantage." [Project Report, Stand Out STEM Students, University of Central Lancashire]

54. The Employability Skills of STEM Ambassadors[8] project involving the Universities of Bath, Exeter and Plymouth worked with two STEMNET contract holders and not only trained 65 student ambassadors by the time their final report was produced, but also sought to help them develop and better articulate key employability skills. A range of resources to enable STEM ambassadors to reflect upon their experiences were developed, and a cohort of 15 students were trained to be trainers of future new STEM ambassadors. The managers of three university STEM ambassador schemes have committed to using the developed resources, and the STEMNET contract holders are now utilising these materials as part of their own training activities.

[8] http://www.exeter.ac.uk/students/ambassadors/HESTEM/

55. Working with STEMNET has not only enabled the joint delivery of mutually beneficial activities to occur but it has also enabled STEMNET to support the dissemination of project outcomes, and where appropriate, embed these within their own work:

"Externally, we have been pleased to hear from STEMNET that there are plans to use the videos in their activities." [Project Report, Becoming a STEM Enthusiast, University of Exeter]

56. A key feature of the work of the South West Spoke was around enhancement of the public engagement activities of the higher education sector, and building collaborations with community groups and third sector organisations to support university outreach activities. From projects that first started in the South West, the Programme's delivery model meant that a number of these were able to be transferred more widely across the higher education sector, and in the case of the work with community groups and third sector organisations [Case Study 14], national coverage was achieved by working through the other Spokes.

57. An example of an innovative approach was seen at the University of Bristol which embedded community-based learning projects for third and fourth year civil engineering students to enable them to develop critical thinking skills, understand the wider context of their work, and provide an opportunity to move in a professional environment at the same time as developing a relationship between the University and the local community. Student interns firstly scoped 11 research projects in community settings and in partnership with 8 community and third sector organisations; 9 of these were successful in obtaining academic supervisors. In total 17 engineering students participated in 6 projects with 7 academic supervisors and 4 community partners.

58. A challenge with such provision is how such projects are successfully assessed, but a learning tool[9] developed by the National Co-ordinating Centre for Public Engagement (NCCPE) was used to assess these projects within the academic framework. The University of Bristol has now developed a list of 11 community partners willing to work on collaborative projects.

"…the University is looking to roll out engaged learning in other departments and encourage sustainability for these types of projects. The initial idea is to investigate adapting the model for use in the School for Policy Studies, as well as continuing the work in Civil Engineering... As such, it is highly likely that community based projects will continue. This includes the continuation of projects with current community partners who are looking to maintain links." [Project Report, The Challenges and Opportunities of Incorporating Community Based Learning into STEM Subjects, University of Bristol]

59. The Enhancing STEM Academics' Public Engagement Skills set out to enable Masters degree, PhD students and STEM academics to become more effective STEM Ambassadors by developing their transferable public engagement skills through activities and events based around the University of Bristol's work on volcanoes and earthquakes. The project built upon the recognition that many scientists do not possess the skills to interact effectively with primary school students, and in response two training seminars were devised to provide continuous professional development opportunities for staff and postgraduates across STEM related departments in primary school public engagement; the seminars were attended by 53 members of staff and postgraduate students

[9] http://www.publicengagement.ac.uk/how-we-help/our-publications/framework-assessing-learning

from across the University of Bristol. The seminars were supported by the development of a Guide to Delivering Effective STEM Public Engagement[10].

60. Knowledge and good practice arising from the seminars was used to create a range of volcano and earthquake outreach activities for primary schools, activities that were designed and delivered by postgraduate students. Six schools (four primary and two secondary) were visited with a total of 900 pupils taking part in a mixture of both volcano and earthquake workshops. Six postgraduate volunteers took part in delivering the workshops.

"Very recently, a senior and respected lecturer in volcanology has agreed to keep the momentum going by recruiting more volunteers from volcanology and seismology. She has recruited eight volunteers to help develop and deliver her own workshop and would like to help to ensure that both other workshops continue and that more people are involved and trained up. This is an amazing result and something that has slowly materialized over the past year. It wouldn't have happened had it not been for the project." [Project Report, Enhancing STEM Academics' Public Engagement Skills, University of Bristol]

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61. Through the Programme's Practice Transfer Adoption scheme, the project was rolled out to seven universities (the Universities of Birmingham, Bradford, Loughborough, Middlesex, Newcastle, Northampton, and Wolverhampton). Overall, within the seven adopters 11 new formal outreach offers have been created, and nine individuals have been trained as 'outreach champions', with each champion reporting a further dissemination of training to groups of 2 to 13 in number within their institutions.

"…through the practice transfer adopter scheme, we have…Built effective communication with local communities by engaging with many of the local primary schools in North London…Extended both the range of STEM workshops offered to local schools and the availability of STEM ambassadors capable of delivering effective, STEM-specific public engagement activities." [Project Report, PTA Adopter Enhancing STEM Academics' Public Engagement Skills, Middlesex University]

"Outcomes: Dedicated member of staff now up-skilled in primary school STEM outreach… Three distinct workshops have now been successfully developed and piloted and are well suited to both Years 5 and 6…Three PhD students have had a positive experience developing and delivering workshops to primary schools around their area of research…. Plans to train up more volunteers over the summer." [Project Report, PTA Adopter Enhancing STEM Academics' Public Engagement Skills, University of Birmingham]

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62. The seminar sessions have been offered again at the University of Bristol in 2012/13, and members of staff and postgraduate students have been able to participate from across the University, including from disciplines outside of STEM:

[10] http://projects.hestem-sw.org.uk/upload/PE_Guide_-_Final_draft_NG_1509117.pdf

"…I went from thinking that my research area was entirely unsuitable for primary school pupils to having a fully fledged plan for a workshop, which I am really excited about delivering." Delegate, History, University of Bristol

"I came away reassured that my research is suitable for engaging school children, inspired to develop my ideas further and confident that there is support available… Hearing about the experiences of people who teach and who do public engagement was invaluable - I knew very little about the UK school system before, or the attention spans of young children." Delegate, Modern Foreign Languages, University of Bristol

63. Participating in the school and college focused activities of the Programme has helped develop future capability across the higher education sector, not just for ambassadors or those who have received training, but for the members of staff who have undertaken delivery of the activities. Several universities participating in the Chemistry Outreach Package identified one of the reasons for participating was to increase their range of activities available for working with pupils of a younger age, although such enhancement was reported for other projects as well:

"The goal of the project to expand the Department of Chemistry's range and experience of outreach activities to lower age groups and thus stimulate a long-standing interest in science has been achieved. Through the activities we have established contacts with primary schools in the Wokingham area, and have had requests for repeat visits…" [Project Report, Chemistry Outreach Package, University of Reading]

"…it has been useful to strengthen links with local schools, and university staff have viewed the events as good experience of working with younger students." [Project Report, What is Engineering and an Engineer?, University of Liverpool]

64. Based upon their participation in the activities of the Programme, other universities identified how they would change and adapt their future approaches:

"From this October, we plan to begin training more undergraduates to deliver outreach and to begin training postgraduates earlier in the year before they have time to make commitments elsewhere." [Project Report, Chemistry Outreach Package, University of Bath]

Developing Strategic Regional Relationships

65. An overarching aim for the Programme (Box 2.1) at its outset was to support the higher education STEM sector to engage in collaborative activity to increase and widen participation. A key feature of this approach, as described within Section 4, was to enable higher education institutions to work with existing STEM organisations and initiatives, and to engage more effectively with employers, as discussed in Sections 6 and 7. While the UK's universities recruit students and engage in collaborations on a global basis, the Programme sought to encourage higher education institutions to develop new relationships at a local level and use these to better target underrepresented cohorts of learner in a more strategic and sustained manner. The Programme's Practice Transfer Partnerships were a key activity in this regard.

66. Recognising that there existed within Wales particular expertise in relation to working in a strategic and sustained manner with widening participation schools and colleges, a PTP was established to share this practice to colleagues within England led by First Campus at the University of Glamorgan. The PTP provided support to 7 universities within England (Universities of Bradford, Central Lancashire, Durham, East London, Loughborough, London Metropolitan, and York St. John), through resources and mentoring to enable the development of strategic plans for outreach and to enable enhanced delivery:

"As a Faculty committed to establishing a more meaningful and collaborative partnership with local schools – the programme has certainly acted as a catalyst for us to explore new ways of interacting with the schools…" [Project Report, Strategic Regional Working with Schools and Colleges PTP, London Metropolitan University]

"Masterclasses and Subject Tasters will be included in the menu of Widening Participation activities…The offer will be extended to the other WP target schools in the region…The opportunity of the masterclass will be extended to other year groups." [Project Report, Strategic Regional Working with Schools and Colleges PTP, York St. John University]

"The workshop will become a key part of the outreach offering at UCLan's Alston Observatory…When developing future activities for the Alston Observatory, we will seek to work with schools to identify curriculum areas to support…The loan scheme will be extended to include other necessary items of equipment, as identified by teachers." [Project Report, Strategic Regional Working with Schools and Colleges PTP, University of Central Lancashire]

"Working with members of the Science and Engineering Schools at the University, more events will be designed to inspire young people about the STEM subjects. The outcomes of this project will be able to offer guidance into how to structure a successful programme and offer suitable activities." [Project Report, Strategic Regional Working with Schools and Colleges PTP, Loughborough University]

67. The STEM Labs PTP [Case Study 44] at Imperial College London operated as a series of sub-strands of interlinked activity, each led by a single institution. In total, 15 higher education institutions or employer laboratories worked to share expertise amongst current, and future potential providers, relating to the use of university laboratories and facilitates to deliver sustainable in-house outreach

opportunities to hard to reach cohorts. The PTP not only allowed content and activities to be shared, including operational and business plans, but also enabled its participants to explore approaches towards effective targeting of widening participation cohorts, staffing and sustainability models, off-site facilities, and good practice in establishing STEM Lab facilities including in relation to building and planning regulations:

"The ROL [Reach Out Lab – Imperial College London] has partnered with Watford Grammar School to set up a satellite ROL centre in the school grounds. The satellite centre will deliver many of the same activities under the guidance of the ROL but the location now enables schools in Bedfordshire, Hertfordshire and further away from central London to benefit from the activities delivered by the ROL." [Academic Member of Staff, STEM Labs PTP, Imperial College London]

Imperial College continues to maintain the activity of the PTP with a number of current activities either already taking place, or planned, within 2012/13 to maintain the network that has been established.

68. The Programme has sought to enable higher education staff to better understand the impact and effectiveness of their activities by undertaking evidence based evaluations of their work. To help embed such a philosophy more widely, particularly in relation to outreach and public engagement activity, the South-West Spoke worked in partnership with the National Coordinating Centre for Public Engagement (NCCPE) on the Effective Evaluation of STEM Outreach PTP [Case Study 11]. The PTP produced a series of resources, ran national training events which were attended by 145 participants, and developed 'train the trainer' materials to enable this training to be 'cascaded' to others.

"Thank you very much for providing me the opportunity to reflect on and improve my practice in evaluation and the wider public engagement movement. I am a great fan of the programme of learning and will be recommending the NCCPE and using training materials on a regular basis both within my employment role and role as a post-graduate student group member." Delegate, STEM Outreach PTP Workshops

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69. The University Technical Colleges (UTC) PTP [Case Study 12], led by the RAEng, was established in response to a growing phenomenon of higher education institutions being involved in the development and delivery of the 14-19 curriculum. UTCs offer 14-19 year olds the opportunity to take a highly regarded, full time, technically-oriented course of study that is sponsored by a university, and which offers clear progression routes into higher education or further learning in work. As UTCs are sub-regional, taking students from a wide geographical area, they are based around partnerships between universities and employers with many also having further education involvement.

70. During the course of the Programme, only two UTCs were operational, but with the Government having committed to establishing 34, significant activity was underway within the higher education sector to enable their further establishment. With UTCs being focused upon technical qualifications, engineering and technology were always likely to be the focus for many, and of the 32 UTCs currently in existence or in development, 29 are based around these subjects[11]. The UTC PTP established a sustainable community of practice, which continues to be supported by the RAEng, that enabled practice to be shared between successful, and aspiring UTC providers, and which has largely helped to avoid large-scale duplication and fragmentation of expertise.

[11] http://www.utcolleges.org/utcs?page=0

71. A number of universities who were particularly active within the Programme have submitted successful proposals to establish UTCs. For example, the University of Lincoln will work with Siemens Industrial Turbomachinery and Lincoln College to establish a UTC[12], for opening in 2014, focused around engineering and science and with a commitment to achievement in mathematics. Through the Programme the University of Lincoln established a mathematics support centre, and embedded a range of activities within its curriculum, in conjunction with Siemens [Case Study 51], to help graduates enhance their engineering and employability skills. An additional outcome has enabled Lincoln to accredit some of Siemens own internal courses.

72. While it is not possible to establish a causal relationship between involvement in the activities of the Programme and the subsequent development of a UTC, there is, however, evidence that the Programme might have influenced institutional approaches towards UTCs:

"…the work done in this project is likely to inform a proposal for establishing a University Technical College locally, focusing on apprenticeships. In particular, a work-based degree programme may become the natural path through HE for graduates from the UTC." [Project Report, Professional and Industrial Degrees: Shaping Curricula Through Improved Employer Engagement, University of Exeter]

Work is now underway to establish the South Devon UTC[13] by the University of Exeter, South Devon College and Teignbridge District Council. Additionally, the Department for Education has approved the University of Birmingham's plans to establish the 'University of Birmingham School and Sixth Form'; the school will reflect the University's values and will have a STEM focus. The engagement of universities who have actively participated in the Programme's work to increase and widen participation with the UTC developments provides a further opportunity to aid the sustainability and wider embedding of the activities undertaken.

73. With regional collaborative approaches to providing education and skills being developed through the UTC initiative, the Programme sought to further develop sustained relationships between schools and colleges and universities that would result in tangible changes to practice. Thirteen Teaching Advisory Boards (TABs) were established [Case Study 17] with a remit to explore the interface between schools and universities, help STEM departments keep abreast of changes to pre-university curricula, and communicate university admissions priorities to schools and colleges. The TABS were also designed to increase the awareness of teachers of the skills and competencies required by STEM employers.

74. Academic members of staff involved in the TABs have reported gaining an increased awareness of changes in the 14-19 education landscape, and in several cases this has impacted on the design of programmes and admissions procedures. Similarly, the majority of participating teachers say they have gained better understanding of the skills needed for university study and the applications of STEM within UK industries. Given the benefits offered, the universities involved have made a commitment to ensuring the continuation of the TAB activities.

75. Each University implemented their TAB in a slightly differing manner to reflect institutional policies and approaches, but what is evident is that while these were relatively small scale activities within the context of the Programme, the available evidence suggests they have had a significant effect upon informing institutional practices, certainly at departmental and faculty levels:

[12] http://www.lincoln.ac.uk/news/2012/05/519.asp

[13] http://emps.exeter.ac.uk/utc/

"…In particular our Maths curriculum for first year teaching has undergone a review… First year entry requirements have also been revised with respect to the BTEC National Diploma curriculum…We have revised our programme of Engineering schools' liaison activities and have invited the TAB partners to be partners and attendees in future events…Connected with the schools' liaison activities were able to produce a series of study aids (developed directly with our TAB members) to aid the teaching of physics and mathematics…We plan to continue the work of the TAB by inviting the members to an annual working group on the School/University interface. We envisage that the working group size will grow to reflect a more diverse cross-section of post-16 education." [Project Report, Teacher Advisory Boards, University of Kent]

"…We will be making changes to the way we run some aspects of our first year course next year…We are now including more careers advice in our outreach lectures…We will be introducing an Applied Physics option in our fourth year, which will involve links with industry. We will make the lectures from industrialists open to teachers, and will try to make at least one of them fall at half term." [Project Report, Teacher Advisory Boards, University of Nottingham]

76. At the University of Reading, the TAB was used as an opportunity to rethink the outreach model, and to explore whether the offering was attractive enough and whether other topics and subject areas should be developed. Following the discussions, which were held with a broad range of local schools, different types of outreach activities were planned which were informed by practice and curricula within schools. At the University of Leeds the TAB helped the Faculty of Mathematics and Physical Sciences identify a large number of staff interested in engaging with schools and colleges. This in turn led to greater focus on the Faculty's school engagement strategy, and findings from the TAB have since been embedded within this strategy. A series of new activities also emerged including the establishment of summertime activities and a summer school; these will be sustained by the appointment of a new education engagement officer within the faculty. At the University of Birmingham school teachers participating in the TAB have been given access to facilities and teaching at the University. There are further plans to invite teachers onto campus to assess laboratory facilities and to adapt the accompanying undergraduate worksheets so pupils can do experiments at the right level. Examples of these adapted workbooks have already been previewed and discussed at TAB meetings.

77. A Teaching Advisory Board was also established at the University of Bath through the work of one of the RSC's Teacher Fellows. The Teacher Fellow scheme was extended to encompass four year-long appointments at the Universities of Bath, Durham, Leicester and Manchester in chemistry, and in Wales two short-term teacher fellows were appointed in mathematics (Universities of Cardiff and Glamorgan). In the North East a variation on the Teacher Fellow model was implemented which meant that teachers remained in their schools for part of their time while undertaking their Fellowship; at the University of Sheffield, Teacher Fellows were introduced into the Department of Physics & Astronomy and the School of Mathematics & Statistics, and at the University of Sunderland, the focus was upon supporting the transition of students into higher education from the new BTEC Engineering Diploma.

78. The remit of the Teacher Fellows was broad and reflected the priorities of their host department, but common objectives involved improving retention, enhancing teaching and learning and in all cases developing links and dialogue between higher education staff and schools.

"…in terms of impact in the local region, a key factor cited in one instance was the establishment of a 'Teacher Development' group, which it was argued would help to facilitate practice transfer between schools across the region. The following example was offered by way of illustration. A recent topic of discussion by the group was the development of learner independence in order to better prepare students for entry to HE. Following the meeting two schools reported that they gained funding from their Governors for extra library resources (including new Chemistry textbooks), and that a teacher had developed a series of booklets for use in schools that were similar in format to the resources given out to undergraduate students in university lectures." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

For the shorter-term placements, the Teacher Fellows typically examined existing provision as students make the transition to university, and made recommendations to the host department. The Chemistry Teacher Fellows, working in conjunction with other colleagues in their host departments initiated changes to university practice even if they were hard to quantify:

"For example, one STF argued that she had helped to raise the profile of teaching and learning at a departmental level, but accepted that this was very hard to measure: 'With me being here teaching and learning has been talked about a lot more, but you can't show that on a piece of paper – you can't show that as an impact necessarily.'" Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

79. At the University of Bath a core focus was upon the use of assessment and student feedback in university teaching, and bridging the gap between what is provided at school and university by utilising strategies familiar to the students. A simple idea that has been successfully implemented across the department is through the introduction of personal whiteboards to increase student engagement in tutorials and lectures. A series of student focused resources for use within the virtual learning environment were developed to act as an introduction to the first year lecture courses; these have also proved useful to A-level students.

"Within the School, plans are already being considered on how some of the suggestions might be developed and embedded into current provision. Furthermore, the project has acted as a reminder of the importance of developing strong links with those involved in the teaching of mathematics (not just the students) prior to university study." [Academic Member of Staff, Teacher Fellow Host Department, Cardiff University]

"…this project has meant that individual practices have been developed and the Level 1 university teaching is now better aligned to the incoming students than before…the dialogue between school/college and university has provided invaluable partnerships that may not have developed without the project and will be sustained beyond the life of the project." [Academic Member of Staff, Teacher Fellow Host Department, University of Sheffield]

"The project has provided an opportunity to establish an enhanced and meaningful dialogue between staff in the engineering departments at the University of Sunderland and Tyne Metropolitan College…The gaps highlighted between the engineering curricula at FE and HE through the mapping exercise will be addressed in the University's Engineering subject review to be undertaken in the academic year 2012/13." [Academic Member of Staff, Teacher Fellow Host Department, University of Sunderland]

80. To support the activities of the Teacher Fellows, the RSC established a pan STEM network and a one-day national conference was held in November 2011. The RSC will continue to support the network of Teacher Fellows to enable them to meet at least twice per year to share best practice and discuss their ongoing work.

Developing Resources and Approaches: Role Models & Activities

81. While the Programme built upon a range of proven practices and approaches, it also identified areas where the development of further resources and materials were necessary to support activities to increase and widen participation within the higher education sector.

82. 'HerStory'[14] created an online resource for women and girls with accessible information highlighting progression routes into, through and beyond engineering higher education. A key feature of the online resource is that it incorporated a broad range of role models, including those following non-traditional routes, and outlined how they had analysed available options and arrived at choices to suit them. A project led by the University of Plymouth created 24 video case studies of adults who returned to higher education in science, technology and engineering via different routes such as foundation years, access to HE diplomas and Open University units. These resources have been

[14] http://www.wiset.org.uk/index.php?page=herstory

integrated as part of the Lifepilot website[15] which is aimed at supporting the progression of adults into higher education.

83. High quality and tailored information, advice and guidance resources are important to encourage students to consider the study of the STEM disciplines at university level, and there is a need for higher education ambassadors to have access to such materials to support their activities. A series of careers articles, case studies and video clips, including examples that describe modern mathematics research have been produced and made available on the Mathscareers website [Case Study 26], which was first enhanced as part of the More Maths Grads project. The Being a Professional Mathematician project, led by the Universities of Greenwich and Birmingham created not only teaching materials and guidance as to how these might be incorporated into the undergraduate curriculum, but also a series of case studies of role models. In a similar approach, and linked with its work on Integrated Sciences, the IoP developed a series of video resources highlighting what research physicists do within their working lives[16] and the careers available to those who have studied physics to A-level or higher[17].

84. While such resources are well accessed, for example Mathscareers currently receives over 16,000 visits each month, the Programme's delivery model has enabled these resources to be utilised more widely:

"…Plymouth University and the University of Bristol have committed to using the montage video at their Open Days and Preview Days. Two of the case studies have already featured in Plymouth University's outreach work with Adult and Community Education Centres….This project will continue as part of the Institute for Science Education's strategy for outreach at Plymouth University." [Project Report, Adult Returner Journeys, Plymouth University]

85. The Science Museums project made use of available and new display technology to provide a multi-touch, multi-user table to enable users to explore information about a range of profiles of people working STEM. Applying technology used by the Visual and Spatial Technology Centre (VISTA) at the University of Birmingham in a research context meant that an interactive touch table could be permanently based within the National Space Centre at Leicester to enable students attending with their parents to find out more about the opportunities available following study of the STEM disciplines:

[15] http://www.life-pilot.co.uk

[16] http://www.iop.org/education/higher_education/stem/showcasing/page_54162.html

[17] http://www.iop.org/education/higher_education/stem/careers/page_44405.html

"…the Table provides a positive facility where 'learners, parents and educators can explore and begin to understand the journey from school to university and into the STEM workforce'...Through the use of the University of Birmingham's cutting edge reality technology 'Look Deeper' the materials are readily accessible and can be followed up afterwards by users away from the Space Centre." [External Evaluator, Science Museums, Sheffield Hallam University]

While the table was only implemented within the Space Centre towards the end of the Programme, it was introduced to nine local schools and 272 Year 10 pupils who attended the Careers Day in June 2012. In addition, 11 STEM Ambassadors and 15 teachers have undertaken professional development training as part of a long term programme of careers awareness events being delivered by the National Space Centre.

86. The development of hands on and interactive resources that can be used within a variety of contexts by higher education staff was discussed in Section 4 (in particular the MLOCK and SIAS kits). The development of such resources has enabled members of the STEM community, and in particular representatives from the mathematical sciences, to participate more effectively in such events such as the regional and national Big Bang Fairs. To help support the STEM community engage with science fairs and exhibitions, a good practice guide was also developed[18].

87. The work of the Programme has also stimulated the development of a number of innovative practices towards increasing and widening participation. The Kitchen Science project at the University of Hull [Case Study 19] involved the writing of a play aimed at Key Stage 2 children in which the central characters use simple science, technology and engineering methods throughout their adventures. The play is accompanied by a series of resources, written in a comic book format[19], that describe the methods in a way that is easily accessible to primary school pupils. Another project developed a science and engineering rap[20] that was performed to critical acclaim in a variety of unexpected settings.

"Great stuff. I'm very keen using song for learning or promotion of STEM subjects. FYI I've written about your work on our Learn Chemistry blog... Keep them coming."

"Fantastic. It is going out on all my social networking sites. Excellent."

"What an awesome video! I've blogged it up here (link)."

Selected Comments, STEM & Engineering Raps

The Transition to Higher Education

88. The transition to higher education within the STEM disciplines is one that is acknowledged to be particularly difficult for students, and as such aspects of the Programme's work in this area have already been mentioned within this section. A 2007 report by the National Audit Office[21] identified that, as a group, students studying STEM disciplines are less likely to progress to the next year of study than other students. In response to these findings, and recognising that while the report had been produced some years previously further work was still required, the Transition & Induction Experiences of Widening Participation Students project was initiated at Bournemouth University.

[18] http://www.hestem.ac.uk/sites/default/files/a_user_guide_on_how_to_design_finance_and_run_an_exhibition.pdf

[19] http://www.sci-toons.co.uk/

[20] http://www.youtube.com/watch?v=lqJ1I02TXtA

[21] http://www.nao.org.uk/wp-content/uploads/2007/07/0607616.pdf

89. The project explored existing practice through two seminars which provided participants with an opportunity to learn from research and practice, share experiences and knowledge, and gain tailored information and guidance in specialist areas such as Aspergers Syndrome and equality legislation:

"One of the things that struck me was what an excellent opportunity it was to share tips, strategies and resources that have proven effective in practice."

"As a result I've joined ALDinHE and hopefully will be attending other events."

Delegates, Transition & Induction Experiences of Widening Participation Students Workshops

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To support the seminars a series of briefing documents were developed to provide delegates with an opportunity to learn about other initiatives taking place, for example, the experience of transition to higher education for looked after young people, and peer mentoring for students with a disability. As a final output, good practice guidelines were developed with a particular focus on social and academic integration to enhance transition and induction experiences of new students on higher education STEM Programmes. An additional, and initially unexpected outcome from the project was that it led to the national transfer and embedding of 'Maths Arcade' model first developed at the University of Greenwich [Case Study 43].

90. The work of **sigma** to embed mathematics support more widely across England and Wales was discussed in Section 4 [Case Studies 28 & 29], but mathematics is a particular barrier to transition and progression within STEM. Even when the focus of a project was not necessarily upon mathematics, it was identified as an issue for which a solution needed to be found:

"The involvement of the University of Derby in the diagnostic study has started to have an impact on the teaching of level 4 undergraduates in that the knowledge gained through the study has shown the areas that these students have problems with. This has then allowed the development of support in these areas…The main support being provided is in maths where a drop in maths clinic has been put in place to help students with particular problems and a level 3 maths module has been validated. This module will be available to students who are struggling with maths and need the extra support/ knowledge." [Project Report, The Transition into Engineering: Scoping Diagnostics and Support Tools, University of Derby]

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91. This identified need at the University of Derby arose from an earlier Programme project that had been adopted from the University of Liverpool. The University of Liverpool, in conjunction with the University of Bolton, Liverpool John Moores University, and Queen's University Belfast extended a

diagnostic tool for assessing the knowledge and experience of incoming engineering students for applicants entering engineering courses through less conventional routes, to enable universities to quickly identify their areas of practical and academic strengths and weaknesses. This test was originally implemented at all four partner universities and continues to be used:

"This successful project will be used for future students at all of the partner universities. Other institutions have also adopted the use of the questionnaire. Furthermore, some of the partner institutions are keen to use a modified and open-access entry version of the questionnaire as part of their UCAS recruitment and admissions process." [Project Report, The Transition into Engineering: Scoping Diagnostics and Support Tools, University of Liverpool]

92. At Cardiff and Swansea Universities, working with Mathematics in Education and Industry, an online support course and study guide in mathematics was established for use by students during the period between them obtaining their results and commencing their university studies. The course was established within a virtual learning environment, and made accessible to around 750 STEM students once they had accepted their place at University. The online course was first made available in 2011, and its evaluation collected responses from 285 student users. Student feedback indicated that they valued the resources and wished to have access to the materials for the entire first semester and not just for the period before they commenced university. Swansea University made the course available to students again in 2012, and has plans to do so in 2013 as well.

93. At the University of Nottingham, a different approach was taken to ensuring appropriate mathematics provision was available for engineering students without a recent A-level qualification. The aim was to provide students with individual support from the start of their courses and ongoing supervision to enable them to progress well in their courses rather than fall behind in their studies only to seek support once they are failing. The new proactive approach involves nominated students attending structured tutorial sessions linked directly to core maths topics; the sessions are delivered by appropriately trained mathematics postgraduate, and the intervention is specifically referenced in the University's Access Agreement (Table 8.1):

"This programme fundamentally changes the mathematics provision for non-typical or non- traditional students and gives them an opportunity to strengthen their core mathematical ability, and thereby assist with the transition to higher education…This change also enables admissions tutors and course directors to admit students with non-typical mathematics qualifications onto an engineering-based degree course with greater confidence. They are therefore freer to accept students of high academic potential but who lack some mathematical capabilities." [Project Report, Proactive Intervention for Students with Non Typical Mathematics Backgrounds, University of Nottingham]

The project has been adopted by the University of Exeter who implemented it towards the end of the 2011/2012 academic year. Exeter has already noted its impact in terms of a substantial improvement in the examination marks of the students who have participated, and very positive feedback.

94. While transitional issues exist for students with A-level or International Baccalaureate qualifications, the transition to higher education is perhaps even more difficult for those with

vocational qualifications where the increased variety of study modes or assessment regimes can prove problematic. The trans:it project[22] [Case Study 27] developed a suite of web and paper based materials, in conjunction with staff and students, for supporting those making the transition from further education into higher education, firstly in engineering and latterly in science. trans:it engineering supplemented the generic trans:it materials with an engineering specific content, and trans:it science was particularly developed for those students moving from BTEC Applied Science and related courses in schools and colleges on to physics and chemistry courses in higher education.

"An additional somewhat unexpected benefit has been that the material, though intended for use principally before the students comes into HE, has been of significant benefit to those already in HE on foundation degree, foundation year and similar courses...Further education colleges have adopted the packages for use in tutorials, universities are using them especially within foundation degrees and franchised provision, and numerous individual students are using them not only across the UK but in many countries, as the weekly usage statistics demonstrate." [Project Report, Trans:it Science, University of Bradford]

95. Supporting disabled students as they make the transition to university, and during their studies was also a focus for activity within the Programme. The IoP led a Diversity Practice Transfer Partnership which acted as a focus for the Programme's work in this area; the work of the PTP will continue through the Institute's Diversity and Inclusion Programme, and a national conference has been organised for July 2013. The work of the IoP was also supported by a STEM Disability Transition Group at Royal Holloway London, which continues to provide information, advice and guidance to improve the transition experience for disabled students wanting to study and work in the STEM fields.

96. The Visual Impairment and STEM project, led by the Universities of Bath, Plymouth and Southampton collated a range of existing resources to develop a comprehensive online resource[23] for supporting students with visual impairments. An Accessiblog[24] resource, providing hints, tips and links to assistive technologies used across universities and colleges to support teaching and learning in science based subjects, was established and this continues to be updated, funded via the University of Southampton's LexDis work as part of the Student Centredness Fund. The project also developed a replicable model for an event which enabled 14 young people with visual impairments to engage with science and mathematics, and which offered an opportunity for their parents to be shown the assistive technologies available to help visually impaired students at the University; the event will run again at the University of Bath in 2013.

"The resource has already been requested by the University of Southampton for use on their PGCAP and will be on the list of online resources for staff undertaking the PGCAP at the University of Plymouth thus engendering a cumulative knowledge base around VI and STEM in HE over succeeding years, developing staff knowledge and enhancing curricula." [Project Report, Visual Impairment and STEM, University of Southampton]

97. Mathematics poses particular challenges with visual impairments with mathematical learning resources such as lecture notes, problem and solution sheets often in inaccessible formats. Re-typesetting notes to produce particular formats is time consuming for members of staff, and so a project[25], aligned with the mathematics support centre at the University of Bath developed methods, instructions and examples by which a single master copy may be used to automatically produce

[22] www.transit.ac.uk

[23] http://stem.ecs.soton.ac.uk

[24] http://access.ecs.soton.ac.uk/blog/accessiblog/

[25] http://www.bath.ac.uk/study/mash/maths-access/

accessible resources in a variety of formats. Recognising there existed a range of effective practice at making the mathematical sciences more accessible, a good practice guide[26] was produced and distributed across the STEM disciplines:

"One of the topics we get asked about a lot lately seems to be access to maths and related subjects. I am delighted to see that the ACCESSMSOR working group have produced a document which pulls together much of the current guidance in this area. This is a very timely publication and will hopefully assist a great deal in an area which is obviously one of the foremost accessibility issues in HE at the moment." TechDis Representative

"As a mathematician with Asperger's Syndrome, the description of Asperger's and the problems faced in HE by students with Asperger's mentioned everything I expected it to, and I agreed with the advice given. It will be very useful to have this booklet as a reference because I don't think much attention is paid to accommodating students with disabilities in my department." Academic Member of Staff

[26] http://mathstore.ac.uk/headocs/InclusiveCurricula_0.pdf

Section 6:
The Higher Education Curriculum and Engaging Employers: Provision and Practice

Introduction

1. Ensuring the longer term sustainability of its work was the key driver in how the Programme sought to establish its activities. At its outset, the Programme recognised that if activities were to have a high likelihood of sustainability, they needed to become embedded as a core part of institutional provision and practice. Informing, influencing, and changing the curriculum were therefore critical to the Programme's approach to increasing and widening participation and higher level skills.

2. Given the underpinning nature of curriculum development and enhancement, aspects of the Programme's work in this area are also discussed within the other sections of this report. For example meeting employer needs, and particularly workforce upskilling, is underpinned by curriculum development, as more bespoke changes have often been needed to the delivery approach, curriculum, or institutional practices in order to meet the individual needs of employers, employees, and those wishing to engage in lifelong learning opportunities.

3. There are also many activities that cross the Programme's three strands of activity that are grounded around changes to the undergraduate curriculum. For example the University of Bath, in conjunction with the Universities of Bristol and the West of England, shared good practice through the STEM Communicators project [Case Study 16] with a view to stimulating the embedding of further practice. In this approach, undergraduate students engage with STEM communication activities working with widening participation cohorts or members of the public during outreach activities or science fairs, but in doing so they also develop or enhance skills that will support them with their studies and the transition to the workplace. While the project trained over 100 STEM Communicators, it also either established a number of new STEM Communicator schemes or embedded existing ones more firmly. In both instances, this was achieved through changes to the curriculum:

"The Bath Maths Communicators course is now firmly embedded into the teaching programme…it has moved from being a 'project based' course to a full unit...As an immediate result the number of student applications has substantially increased…A Physics Communicators course has been launched at Bath, inspired by, and using the best practice lessons learned from, the Maths Communicators unit. The first students on this course will start in the academic year 2012-2013." [Project Report, Embedding Accredited STEM Communicator Models, University of Bath]

The project also established a module at the University of Bristol that is now embedded, and building upon this practice, other projects within the Programme have established similar schemes including the University of Chester [Case Study 24], and the University of Central Lancashire who intend to build upon their Stand Out STEM Students project with the introduction of a credit bearing module.

"The Communicating Science Module at Bristol (set up as a first year Physics option as part of the project) will continue. For next year 4, second year students from another Faculty have already signed up." [Project Report, Embedding Accredited STEM Communicator Models, University of Bath]

4. In describing the work of the Programme, this section focuses primarily upon changes to the undergraduate curriculum for full-time learners in relation to learning, teaching, assessment, and skills. A range of approaches were adopted by universities to aid the skills development of their students with a view to enhancing their transition to the workplace and better meeting the needs of employers in relation to their demand for new graduates[1]. Some skills interventions for students were compulsory and credit bearing, others, were voluntary and had no credits attached. Equally, employers were engaged in a variety of ways to contribute to the skills enhancements that were implemented, either as advisors to the changes or contributors in their delivery.

5. Given the range of curriculum focused activities taking place within the Programme, in autumn 2011, and aligning with recommendations contained within the Programme's 2011/12 Business Plan, 'synthesis reports' were commissioned to explore the Programme's approaches and to identify effective practice and learning. Two synthesis reports are directly related to the Programme's higher education curriculum work: a report by Tolley, Greatbatch and Mackenzie entitled 'Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education' and a report by Kettle and Smith entitled 'Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects'; the Regional Action Plan and Legacy Projects were the primary mechanism for delivering the Programme's higher level skills work. Both reports will be published through the University of Birmingham's STEM Education Centre shortly, but their findings are used here to inform the content of this section of the Programme's final report.

Development of New STEM Programmes of Study

6. Through the National HE STEM Programme, new undergraduate courses or modes of study have been created within the disciplines of physics, chemistry and engineering for those wishing to study for a complete Bachelors or Masters qualification on a full-time or part-time basis. While, by the conclusion of the Programme in July 2012, some of these courses had either already

[1] The skills are often commonly referred to as 'Graduate', 'Transferable' or 'Employability' skills.

recruited students or commenced the process of advertising the developed provision, for others, the 'groundwork' has been firmly established for their future launch.

7. Within the Stimulating Physics project, the IoP developed an inter-disciplinary sciences degree, which was designed to give students greater freedom of choice and allow them to work in an academic environment where they can tackle real-world problems by integrating theories and practice from across the sciences. In addition to enabling the students to develop a strong base in the sciences, an Integrated Sciences (IS) degree also allows them to gain the key skills required for future employment in areas such as information technology, problem solving, management, critical thinking, numeracy and communication. At the end of the Stimulating Physics project, the Integrated Sciences degree had been established at London South Bank University and the University of Leicester.

8. Integrated Sciences has now been established as a new undergraduate programme at the University of Bradford[2]. Recruitment onto the course first began for 2011/12 entry, with a further cohort joining in 2012/13; a total of 67 learners are currently registered on the programme. In developing its Integrated Sciences curriculum the University of Bradford received support from the University of Leicester who have been offering Integrated Sciences for a number of years and who have over 100 full time equivalent students on their course; an additional 80 students have also taken Integrated Sciences modules at the University.

9. At the University of Leicester, the development of the Integrated Sciences programme continued with the revision of the laboratory programme, and the production of further resources and materials to support the teaching of physics. In 2012 a review of Integrated Science course was undertaken by the University of Leicester; the course will not only continue to be supported but it will be rebranded as 'Natural Sciences' with a view to increasing the number of students admitted onto the programme.

10. In 2008, Research Councils UK undertook a review of UK Physics[3] (commonly referred to as the 'Wakeham Review') which called for students to have more ready access to applied physics provision. Through the Programme, Applied Physics has been developed at the Universities of Portsmouth [Case Study 46], the University of Bradford[4], and St Mary's University College[5] in conjunction with the National Physical Laboratory. While the Applied Physics degrees at Bradford and St Mary's are currently recruiting for 2013/14 entry, the University of Portsmouth currently has over 80 students enrolled upon its Applied Physics degree from September 2012:

"As a result of this curriculum development project the University of Portsmouth now has a new undergraduate degree in Applied Physics that is founded on developing skills and understanding appropriate to employment in industry and health care…The University has a clear commitment to sustaining the degree and has recently appointed two members of lecturing staff to continue development and delivery of the degree." [Project Report, Applied Physics, University of Portsmouth]

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11. In developing the Applied Physics course, the University of Portsmouth has sought to build upon effective practice from elsewhere:

[2] http://www.brad.ac.uk/life-sciences/careers-employability/integrated-science/course/

[3] http://www.rcuk.ac.uk/documents/reviews/physics/review.pdf

[4] http://www.bradford.ac.uk/courses/view/?c=applied-physics-mphys-4-years

[5] http://www.smuc.ac.uk/undergraduate/applied-physics/

"During the execution of the project, other opportunities have been identified through the HE STEM network that will make a very valuable contribution to the further enhancement of the Applied Physics degree. In particular, the adoption of the Mathematical Modelling and Problem Solving initiative should enhance student's performance across the degree and valuable exchanges have taken place through the related IoP Integrated Sciences and Applied Physics project." [Project Report, Applied Physics, University of Portsmouth]

12. In addition, employer engagement (in particular Astrium, Portsmouth Hospitals' Medical Physics Department, Clanfield Observatory, DSTL and National Instruments) with the design and delivery of the curriculum is a particular feature; much of the interaction was brokered through the establishment of an Industrial Advisory Board:

"Apart from advice and guidance, a valuable outcome of the employer collaborations has been the engagement of industry and health care partners in suggesting and assisting in the development and supervision of industry-related, problem-based projects in the level 5 laboratories and in level 6 project work. Employer engagement has been especially productive in curriculum terms when representatives have been able to visit staff and students in the laboratories and students and staff have been able to visit workplaces."
[Project Report, Applied Physics, University of Portsmouth]

13. The development of Applied Physics at Portsmouth represents a good example of how the Programme's delivery model has enabled institutions to benefit from its work. By establishing a range of activities and then ensuring these are appropriately disseminated allowed higher education institutions the opportunity to select activities and interventions that were most appropriate for their needs. Representatives from the Applied Physics course at Portsmouth participated in a number of the employer engagement workshops established in the early stages of the Programme by the Workforce Development and Lifelong Learning Special Interest Group, integrated the chartered status resources developed by the Careers Practice Transfer Partnership, implemented an Industrial Advisory Board based upon the model developed through the Repackaging Physics project at the University of Salford, and adopted the Mathematical Modelling and Problem Solving project developed by the University of Leeds.

14. In engineering, the Programme was not only able to develop five new degree courses, but was also able to expand an existing network through partnership and collaboration. The Engineering Gateways PTP [Case Study 60], led by the Engineering Council, built upon an existing framework for flexible and innovative higher education provision for engineering employees that resulted in a professional engineering qualification (IEng or CEng). Five universities implemented the framework and collaborated with five existing providers who shared their practices. In addition to the development of a toolkit to support other universities wishing to implement this framework, five new engineering gateway degrees have been created (at the Universities of Coventry, Derby, Greenwich, West of England and Leeds Metropolitan University), and the size of the community of practice has grown:

"All five universities are either already marketing, or will be marketing, an Engineering Gateways type of degree. This brings to twelve the number of providers of Engineering gateways type degrees, which increases the size of the community of practice…Two of the new providers are offering a discipline hitherto not available (building services engineering) to the workforce and for which there is a perceived need." Engineering Council Representative, Engineering Gateways PTP

"…the University was aware of a significant part time market in the region and one that has been frustrated with regard to access and the flexibility of the higher educational offer...A work based solution was considered and remained in our thoughts through the remainder of the year, particularly as one of our staff was working on another aspect of the HESTEM project. When the University was invited to join the project in late 2011, this opportunity offered a means by which to inform our course development process..." [Project Report, Engineering Gateways PTP, Leeds Metropolitan University]

15. Lancaster University set out to establish a hybrid part-time Masters level degree scheme in nuclear and chemical engineering that would not only offer students a traditional experience with the benefits of a part-time format, it would also allow them to meet the requirements of the UK Standard for Professional Engineering Competence. While the project reported that changes to the higher education funding landscape and the global economic outlook meant that delivery of the scheme had not yet commenced, it still impacted upon departmental practices:

"Although circumstances have prevented the piloting of modules that would make up the new hybrid degree courses, the groundwork has been done for their implementation including: the design/validation of the new course(s); the appointment of new academic staff; and, reaching agreement with a significant number of industrial partners." [Academic Member of Staff, Hybrid Part-time MEng Degree Scheme, Lancaster University]

16. At the University of Wolverhampton, in response to concerns from local manufacturing companies regarding a mismatch between the supply and demand for engineering graduates, a new manufacturing degree has been developed in conjunction with a range of industrial partners including Caterpillar, Goodrich, Moog, and Jaguar Land Rover. The Gearing up for Industrial Growth project [Case Study 63] has established a new manufacturing degree, commencing delivery in September 2013, that can be undertaken on either a full-time or part-time basis.

17. The degree will be delivered via work based learning, and with components taking place over 45 weeks, it enables participants to achieve a full degree within two years while also working with local business and industry. The

degree is scheduled to operate on a three semester basis involving learners undertaking three days of study within the workplace and two days study per week in the University. Employers not only provide sponsorship to students but also contribute to the delivery of content, and the provision of work based projects. The University of Wolverhampton degree programme also integrates its activities with the Black Country University Technical College to enable a progression route for learners, and in a manner that enables them to stop-start their studies as their individual circumstances dictate. It has implemented bridging modules to allow a progression route for learners following apprenticeship programmes.

18. An additional successful outcome is that the University is part of a consortium that has recently secured £2 million to develop 'The Skills Factory for High Value Manufacturing' through the UK Commission for Employment and Skills Growth Innovation Fund.

"Some of what we have learnt from this programme has stressed the importance of STEM to our University and local industry and commerce. Our University Executive and Governors have developed a new strategy to form a new School for STEM, which is currently undergoing development." [Project Report, Gearing up for Industrial Growth, University of Wolverhampton]

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19. In developing their new industrial focused degree, the University worked closely with representatives from Swansea Metropolitan University. Swansea Metropolitan University [Case Study 62] have offered successful part-time degrees in manufacturing engineering for many years, but students have needed to enter the programmes at Level 5, requiring them to have appropriate advanced qualifications (such as a Higher National Certificate (HNC) in an appropriate engineering discipline) and some experience. It was apparent there existed a group of employees who were as experienced as these students, but lacked the qualifications necessary to permit them entry to the part-time degree programme.

20. In partnership with Glyndŵr University, an intensive fast-track programme of study, comprising 60 credits in mathematics and engineering science at Level 4 was developed. The programme is delivered on Friday afternoons and evenings, to minimise time out of work for the students, over an extended academic year (42 weeks). Recognition of prior learning and experience provides exemption from Level 4 modules in manufacturing technology and engineering applications, and students who successfully complete the programme are able to enter the Bachelors degree at Level 5 alongside the HNC qualified students.

21. Swansea Metropolitan University recruited six students to the course in September 2011, although this was below the initial target of ten. The reasons for this were due to difficulties experienced by employers in releasing students from work, and the uncertainty amongst both employers and employees regarding the fee rate that would be set for the course in subsequent years. At Glyndŵr University the course was delayed from its planned start date of September 2011. One of the reasons was due to the higher cost of delivering the programme which meant it proved initially unattractive to employers and employees; when the fee was reduced, 11 learners were recruited for a February 2012 start.

"A pilot group successfully completed the programme. Students progressed to Level 5 and appear to be doing well. There seems to be no difference in their performance from the more highly qualified students who were admitted directly to Level 5…The viability of this fast-track programme has been demonstrated and has now been fully incorporated into the part-time BEng portfolio... A cohort of Level 4 students was recruited again in the 2012/13 academic year, suggesting that it is sustainable." [Academic Member of Staff, Fast Track Level 4 Progression Pathway, Swansea Metropolitan University]

22. Although there has been some decline over several decades, the metals industry (particularly steel) remains vitally important to the manufacturing sector of the economy in Wales, with Tata Steel being the largest private sector employer. In recent years there has been concern regarding the need to supplement the traditional recruitment of graduate materials scientists with the development of talent from within companies. Swansea University has well-established Engineering Doctorate, Masters, work based learning and full-time undergraduate programmes, but no part-time provision at undergraduate level. To address this gap and complement the provision at Swansea University, Swansea Metropolitan University developed a part-time programme in Materials Engineering. The programme consists of an integrated HNC/Foundation Degree/Bachelors degree, providing students with a variety of entry and exit points.

23. Swansea Metropolitan University worked closely with Tata Steel and other companies to design and validate the part-time programme and recruit a pilot cohort of students. Students came from a variety of backgrounds, some with A-levels, some with technical qualifications and some through Swansea University's work based learning course. The delivery model is aligned with the successful model of the other part-time engineering programmes at Swansea Metropolitan University in that it takes place on Friday afternoons and evenings over an extended academic year.

"This project has enabled an important part of the proposed 'skills escalator' for the metals industry in Wales to be developed. As a result, there is now a comprehensive portfolio comprising EngD, full-time and part-time MSc and MRes, full-time BEng, part-time integrated BEng/FD/HNC, short course provision and work based learning activity in Materials Engineering in Wales, provided by Swansea Metropolitan University (SMU) and Swansea University." [Academic Member of Staff, Steel Academy, Swansea Metropolitan University]

24. The Steel Academy model is transferable between institutions and employer sectors. While developments are still in their early stages, Swansea Metropolitan University has developed a partnership with Yeovil College, and a likely outcome will be a similar integrated undergraduate programme, specialising in polymers and composites to address the needs of another industrial sector. Further, a partnership has been developed with a Welsh further education college to develop work based learning activities and a HNC in Welding Engineering.

25. At the University of Hull, there previously existed a part-time Foundation Degree in Chemical Science that was delivered through day-release study. Employers within the Yorkshire and Humber region reported that day-release courses were becoming untenable in the current financial climate and that participation in higher education would increase for those working in the chemical industry if the mode of delivery was more flexible and included more work-based learning. In response, the course was redesigned and launched for distance learning [Case Study 61]; over 30 students are now participating by distance learning in the foundation degree. The 'top-up' to BSc level was also

previously only available through day release, but following the success of the initial development, the University worked with the Programme to develop a further 120 credits of material to enable this also to take place by distance learning; additionally a distance learning foundation stage for those without A-level chemistry is now also available.

"The experiences of the Project Team in the department of Chemistry of online course delivery are impacting on the department of Engineering within the Faculty of Science. The department of Engineering currently delivers a foundation degree by day-release. Staff within the department are considering moving to a blended approach for their own course." [Project Report, Embedding resources for distance learning, University of Hull]

A similar model has also been implemented within engineering through a collaboration between Bournemouth University and Bournemouth and Poole College where engineers already in employment, and with a variety of prior qualification levels, can now gain Bachelors and Masters levels qualifications by part-time distance learning mode.

26. The IoP has continued to work with the University of Salford on its Repackaged Physics Degree [Case Study 32] which was first initiated during the Stimulating Physics project. The degree curriculum has been heavily influenced by an Industrial Advisory Board which not only provides advice, but also acts as a source of guest lectures and industrial visits. Problem based learning has been embedded throughout the degree, and this happened in conjunction with the University of Leicester based upon their expertise within Integrated Sciences. There is evidence that the Repackaged Physics Degree is proving attractive to potential students with an observed increase in applications to study Masters and Bachelors level physics degrees. For 2010 entry, 111 applications were received, and for 2011 entry this had increased to 185; applications for 2012 entry were 52% up on those for 2010 entry. Bringing together the learning that has been identified from undertaking this work at the University of Salford, a good practice guide for other physics departments has been produced[6].

Embedding University Wide Mathematics and Statistics Support

27. The work of the **sigma** network was first discussed in Section 4 of this report, but a key feature of its activities involved the establishment of 22 new mathematics support centres and the enhancement of a further six to increase the scope of their current activities [Case Study 28]. Mathematics support centres provide a friendly and informal location where students can 'drop in' to receive help with the mathematical and statistical content of their courses. Mathematics support centres have been established as a positive response to well-documented challenges with the teaching and learning of mathematics at the transition to university across a wide range of disciplines and in all types of higher education institution[7].

28. As the support provided is typically in addition to the mathematics teaching students receive as part of their undergraduate programmes of study, and given they support students from a range of disciplines, the work of mathematics support centres per se is technically not part of the formal higher education curriculum. However, it is known that following many years of research[8] they are now an important, and essential mechanism, for supporting student learning of mathematics across a wide range of disciplines, and it is appropriate they are considered here, particularly in terms of their embedding as part of an institution's student support provision.

29. In England, 14 mathematics support centres were established through **sigma**, and the data collected from the lead of each centre indicates that almost 2,600 collective student visits were

[6] http://www.iop.org/education/higher_education/stem/resources/file_44401.pdf

[7] See for example 'Measuring the Mathematics Problem' (Engineering Council, 2000), which recommended that *'prompt and effective support be offered to students whose mathematical background is found wanting'*.

[8] See, for example: http://www.mathcentre.ac.uk/resources/uploaded/52487-evaluation-of-msc-7.pdf

supported by the end of July 2012. Of the six centres that received enhancements through the Practice Transfer Adoption scheme, an additional 138 visits were supported even though increasing capacity was not the primary aim of the scheme. While differing institutional environments and plans for the continuation of provision have resulted in the support centres adopting differing approaches to their development and delivery, each university was required to provide a clear, and explicit commitment to continue the work of its centre into the future; as a consequence, the sustainability of the developed centres is strong. This is further reinforced by the references to mathematics support provision within the Access Agreements of many of the universities involved (Table 8.1):

"To be eligible for sigma **funding in either round an institution had to provide matching support, in cash or kind. Additionally, institutions receiving support from the second round of funding had to undertake to support the mathematics support centre in the academic year 2012–3. Hence there is an understanding at an institutional level that the centres will continue to operate in the academic year 2012–3." Final Report,** sigma **(2012)**

30. Further evidence also exists relating to the longer-term potential for sustainability. For example, at the University of York [Case Study 30], the report of the 2012 Quality Assurance Agency (QAA) Institutional Audit noted **"the successful establishment of the Maths Skills Centre to support students across a wide range of disciplines"** to be a feature of good practice. Additionally, other centres have become embedded as part of mainstream provision indicating an influence upon wider institutional practices:

“In the academic year 2011–12 the Mathematics and Statistics Support Centre became part of the University’s Learning Development function and rebranded to match its style.” Extract from sigma **final report (2012) commenting upon the mathematics support centre at the University of Lincoln**

31. For the centres established in Wales, collective information relating to students visits is unavailable, but the individual reports from each indicate student participation was not as high as might have been expected. This is not surprising as it is known there will inevitably be a period where awareness of a centre amongst the student cohort needs to grow. Despite this, the available evidence indicates that a minimum of five of the eight universities who developed centres in Wales have noted the potential benefits and will continue to support their activities into 2012/13:

“The present activities, namely a Mathematics Clinic and a dedicated web-site, are SMU’s response to tackle the decline in mathematics skills at university entry level. Although not a huge number of students have used the Clinic yet, we believe that as the Clinic develops and becomes part of SMU’s culture it will play a vital role to help bridge the gap and ease the transition between A-Level studies and degree courses. Therefore SMU is committed to develop and maintain such a support service in the years to come.” [Project Report, Mathematics Support Centre, Swansea Metropolitan University]

32. In several of the universities there is desire and commitment to further expand the developed mathematics support provision, particularly within Swansea University which developed two mathematics support centres:

“The College of Engineering intends to continue to operate its mathematics support activities in the academic year 2012-2013. As a minimum the College plans to offer the same mathematics support workshops that ran in this years academic session…” [Project Report, Mathematics Support Centre 1, Swansea University]

“The College of Science has agreed to fund drop-in sessions for the 2012/13 academic year…There are early stage discussions about establishing a University wide drop-in centre, possibly housed within the library, which would combine the provision offered by the Colleges of Science and Engineering and extend it [to] provide support to the whole student body.” [Project Report, Mathematics Support Centre 2, Swansea University]

“A recommendation to the School and Faculty will be to expand the provision to a wider range of courses that would benefit from the maths support sessions.” [Project Report, Mathematics Support Centre, University of Wales, Newport]

33. In the instances where is appears unlikely that the mathematics support centre will continue, the experience of providing mathematics support has had an impact upon the wider practices of those staff members involved that will continue into the future:

"Unfortunately, due to the current financial situation and a consequent lack of funds for staffing costs, there is no prospect of money being made available to support such activities in the future…[However] Several of the staff engaged on the BSc Observational Astronomy have now attended courses on online…and far greater use will be made of maths-based problem sheets on modules in future…Within Police Sciences, [Name Removed] has developed some support materials which will be used in future as part of his teaching on that award (and in support of project work using SPSS)." **[Project Report, Mathematics Support Centre, University of Glamorgan]**

34. While the mathematics support centres were established through the Programme to support students from the STEM disciplines, they were usually made accessible to students from any discipline within the university in which they were based. This indicates a growing trend in which the constituency of those seeking to partake in mathematics support is broadening. Ten years ago such support might have only been accessed by students from engineering, mathematics and physics; nowadays, students from business, social science or health-related disciplines also regularly visit mathematics support centres. There is another aspect to this broadening of participation in that while mathematics support was originally conceived for students experiencing difficulties at the transition to university, these facilities are being increasingly accessed by more able students who are seeking to secure the highest grades. The mathematics support model is now one of enhancement as well as support.

Enhancing University Learning and Teaching Practices

35. In 2008, the Higher Education Academy Subject Centre for Physical Sciences undertook a review of the student learning experience in chemistry[9]. While focused upon the discipline of chemistry, the issues collectively highlighted as students make the transition to university underpin all of the STEM disciplines represented by the Programme:

"Students often arrive with poor practical skills because of their limited use of laboratory equipment, or the tendency in schools to rely on demonstrations. The weakness in problem-solving ability probably stems from the difference in teaching methods between schools and universities. Directors of Teaching comment that universities expect independent learners, whereas at schools students are teacher led." **Review of the Student Experience in Chemistry, Physical Sciences Subject Centre (2008)**

36. While the issues relating to laboratory skills are not applicable to mathematics, the review also highlighted concerns relating to the mathematical skills of new undergraduates. The Programme's work in this area through **sigma** has been discussed already with the development of a national

[9] http://www.heacademy.ac.uk/assets/ps/documents/subject_reviews/chemrev_final.pdf

mathematics support network [Case Study 29], the development of the new mathematics support centres, and a range of pre and post-transitional interventions to support the non specialist learning of mathematics (see Section 5).

37. Context and Problem Based Learning (C/PBL) are research based learning methods where students are encouraged to solve problems, both theoretical and practical, which are grounded in a real world framework. The problems are often complex and open-ended, requiring real thought and enquiry. A key feature of C/PBL is that students work together in small groups, and the role of the staff member is to facilitate these interactions, guiding learning rather than 'transmitting' information. Group working enables the students to test and develop their level of understanding as they discuss their theories and findings with others. While C/PBL approaches can help students with the transition to university study, they also help address the transition to workplace as it mirrors how people work in the real world; this was a key aim for the RSC's work:

"There was common understanding amongst those questioned that the principal aim of the CPBL resources is to further students' employability by increasing their industrial awareness, developing their capacity for independent learning, and improving their problem solving, team working and communication skills." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education commenting upon Royal Society of Chemistry's C/PBL work (2013)

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38. C/PBL formed a core part of the Chemistry for our Future and Stimulating Physics projects, and was a key activity for wider transfer and embedding within the higher education sector through the Programme. One of the initial activities undertaken was to package the previously developed materials into a form suitable for immediate use by other members of academic staff with their students[10], before commencing the process of rolling these out more widely.

39. The Menu of Activities proved an initial opportunity to make some of the previously developed resources more widely available, and five universities opted to implement problem based learning modules in physics and chemistry. All participating universities indicated that the modules would run again during the academic year, and several project leads indicated that the use of C/PBL would increase within their institutions:

"This activity will be part of the skills module next academic year. Based on the success of this activity the plan is to adopt a further group based C/PBL activity into Year 1 chemistry from 2011/12." [Project Report, Context and Problem Based Learning, Nottingham Trent University]

"Problem Based Learning within physics teaching at UEA will be more common in the future as a result of this case study." [Project Report, PBL Packages for Active Learning, University of East Anglia]

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40. Following the success of the initial C/PBL activity at Nottingham Trent, the University participated in a further Programme project to enhance the employability and skills of graduates from the disciplines of chemistry, physics, forensic science and computing. One of the activity strands of this project was to further embed the use of C/PBL as part of a significantly revised programme:

[10] http://www.iop.org/education/higher_education/stem/problem-based/page_55225.html

"This has been a year of extensive development within the School of Science & Technology (SST) at NTU driven by a range of internal and external factors. This HESTEM project 'Enhancing Graduate Employability and Skills Building Effective STEM Graduates' has been a key factor in informing the resulting developments and has impacted on a significant part of the character of our future provision in terms of changes to types of assessment, increasing the profile of problem-based learning (PBL) in our curricula and broader implementation of skills portfolios." [Project Report, Building Effective STEM Graduates, Nottingham Trent University]

Similarly at the University of East Anglia, an unexpected outcome emerged relating to peer support amongst undergraduates from different cohorts:

"I was particularly impressed with the way the Natural Sciences students helped the Foundation Year students. This is something I will certainly follow up in the future. Foundation year workshops are usually supported by staff and postgraduate students, but following this case study I would like to see if Natural Sciences students could also help." [Project Report, PBL Packages for Active Learning, University of East Anglia]

41. Recognising that a lack of experience or an understanding of C/PBL methodologies might prove a barrier to staff engagement the IoP and the RSC sponsored the piCETL summer workshop on C/PBL as a means of encouraging further departments to consider its implementation. Twenty participants from the higher education sector attended with bursaries made available to enable 14 higher education staff to attend; in return delegates trialled C/PBL materials and produced case-studies of their experiences. The summer workshop continues to run with a further event planned in June 2013[11].

42. An additional ten C/PBL [Case Study 33] resources highlighting the major role of the chemical sciences in addressing global challenges outlined in the RSC's roadmap, 'Chemistry for Tomorrow's World' were produced. To not only encourage their uptake but also to encourage higher education institutions to engage in the delivery of the curriculum through C/PBL, expressions of interest were sought from those wishing to participate in the trialling of these resources. Over 71 expressions of interest were received demonstrating the demand for this kind of activity, and a matching process resulted in 20 trial teams being established. The trial process was designed to enable the transfer of good practice from C/PBL experts to novice practitioners and the embedding of this pedagogy into the chemistry higher education curriculum.

"Those questioned were also positive about the impact of the project, not least because of the number of HEIs (twenty plus), which previously had made limited or no use of CPBL that had already been involved in developing and piloting one or more of the resource units…the development process itself was highly collaborative...Consequently, the project provided those who participated in it with an opportunity to further their own personal and professional development – not just in terms of their knowledge and understanding of the design and delivery of CPBL but in the planning and management of change." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

[11] http://www.physics.le.ac.uk/PBLSummerSchool/

43. The C/PBL resources were trialled or implemented by approximately 23 higher education institutions, with around 950 students participating in the activities. The trial process has proved successful in encouraging more chemistry departments to engage with problem based learning methods. 15 of the 19 individuals who responded to the online evaluation survey either 'strongly agreed' or 'agreed' with the statement: **"Our institution will be embedding this and similar resources in the curriculum in the future."** 18 of the same 19 individuals 'strongly agreed' or 'agreed' with the statements: **"This process inspired and supported me to try some new academic practices"** and **"This process made me want to adapt and adopt some of these ideas in my own practice."**

"The trial was a success and it has now become a permanent part of the curriculum. The activity was easy to adapt to our needs with very few changes." [Academic Member of Staff, Chemistry C/PBL, University of Salford]

44. The extent of the activities taken to further C/PBL by the Royal Society of Chemistry has also contributed to the development of an active national network:

"…the interactions, both formal and informal, between all those involved in the process has helped to build a strong 'community of practice' centred on important aspects of teaching and learning in chemical sciences." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

45. With support from the IoP and utilising the expertise at the University of Leicester, C/PBL resources have been embedded within those institutions participating in the Repackaging Physics, Integrated Sciences and Applied Physics degree programmes.

"The projects funded by the programme provided evidence of a discernible shift in pedagogy towards problem based learning and group project work allied to stronger links with industry." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

46. In Physics, a further wider issue was identified that required attention. Many quite high performing students are able to demonstrate technical skills in the manipulation of equations, but lack the ability to articulate the implications of their results in conceptual terms. High performing students can also be quite poor at solving problems that are not already set in the language of a pre-formed model, or at articulating the hypotheses underlying the solution to a problem. Less able students

often attempt to learn mathematical material by rote without conceptual understanding. In all cases these students are ill prepared with the relevant skills for problem solving in employment. Brokered by the Institute of Physics, the University of Leicester, in conjunction with the Universities of Hull, Durham, Hertfordshire, Edinburgh and St Andrew established a project [Case Study 31] to address this issue through a variety of approaches[12] which were embedded within the curriculum of the participating universities; around 340 students have been involved in the pilot:

"Their experience of the lab has changed quite considerably since we introduced this initiative." [Academic Member of Staff, Conceptual Understanding in Physics, Durham University]

"It is intended that some of the areas will be extended at Leicester e.g. the use of concept tests; the use of screencasts and the development of a further suite of these; the use of the modelling approach; the use of ISEs [Interactive Screen Experiments] for laboratory support." [Project Report, Conceptual Understanding in Physics, University of Leicester]

47. The project has already resulted in a further national curriculum development:

"The lead University has already initiated a new project with the IoP on support for a new curriculum for Quantum Mechanics to do specifically with conceptual understanding, thereby providing an important spin-off." [Project Report, Conceptual Understanding in Physics, University of Leicester]

48. In Mathematics, furthering problem or puzzle based learning was identified as one of the priorities from the January 2011 HE Mathematics Curriculum Summit. However, the lack of suitable supporting materials, problems and solutions, was identified as a barrier by departments to engaging with this approach, particularly in relation to problem based learning with an industrial focus. As a consequence, four linked projects were established that developed a series of high quality resources [Case Studies 34 & 35] for use by mathematical sciences departments. All four projects only completed towards the end of the Programme, and as such, there has been insufficient time for these to be trialled more widely with students. However, the departments who have produced these resources have identified they intend to use them in the future, and, for example, plans are in place to make the puzzle based learning guide available to all first year undergraduate STEM students at the University of Birmingham.

49. Within the School of Physics and Astronomy at the University of Leeds, a concern was identified with the ability of new undergraduates to apply mathematics to model real world scenarios and solve problems; a key skill for both undergraduate progression and employment.

"…by getting mathematical modelling and problem solving into the programme at such an early stage (Year 1) it will impact on the whole course all the way through to the projects the students do in Year 3" [Academic Member of Staff, Mathematical Modelling and Problem Solving – Civil Engineering, University of Leeds]

[12] http://www.physics.le.ac.uk/physicsconcepts/index.shtml

50. While the concept for the project was initiated at the University of Leeds, the Universities of Manchester, Keele, and the West of England also identified work in this area as a priority, and a collaborative project was formed and led by individuals who had not worked together previously. Through the Practice Transfer Adoption scheme, the project was extended to four further universities and an additional nine departments, including six at the University of Leeds [Case Study 34].

51. The framework for the project allowed each university to offer a slightly differing approach to reflect individual needs and priorities. At the University of Leeds, the approach within the School of Physics and Astronomy involving aiding the development of modelling and problem solving skills amongst 62 first year undergraduate students through the teaching of Newtonian mechanics. This University of Leeds intervention was independently evaluated by a member of staff from the School of Education at the University of Manchester to ascertain its impact upon student learning:

"The course managed to re-introduce Mathematical Modelling & Problem Solving (MM&PS) into the undergraduate student experience in an arguably 'authentic' course in mechanics in first year Physics…Students dispositions (and probably their awareness) of Mathematical Modelling significantly increased between measures 'before' and 'after' the course." [External Evaluator, Mathematics Modelling & Problem Solving, University of Manchester]

The success of the project has now underpinned a new first year module 'Mathematical Modelling and Problem Solving' which is offered to all first year undergraduates who wish to develop their modelling and problem solving skills by undertaking investigations and writing accessible, but technical reports of their findings, another key skill required for the workplace.

52. Within the other three initial partners, the implemented approaches have all resulted in sustainable changes to the undergraduate curriculum:

"Employers and lecturers, on the other hand, regard problem solving as the act of modelling and then solving unstructured problems. We sought to address these issues by introducing problem solving with contextual problems, then progressing on to problems that require a qualitative rather than quantitative analysis, before finally developing the students' modelling skills. Keele University's Mathematics Department developed a new first year module which aimed to develop these skills and use innovative methods that allow students to express their creativity…" [Project Report, Mathematical Modelling and Problem Solving, Keele University]

"We will continue to run the Mathematical Workshop in its current form for the next few years. However it is essential that students have an opportunity to further develop their modelling and problem solving skills at a higher level. To this end we intend to introduce [in 2013/14] a second year course in mathematical modelling. This will involve group project work where students develop, solve and evaluate models based on real world problems. A similar course for MSc students will run in 2012-13 and we will be able to learn valuable lessons from this in terms of delivery and assessment." [Project Report, Mathematical Modelling and Problem Solving, University of Manchester]

> **"Materials developed in this project will be used on the 30 credit module Mathematics and Engineering Principles which will combine the development of mathematical techniques, modelling and engineering principles in dynamics and stress analysis. In this new module we intend to go further in promoting the modelling process than was possible in the current module and will be able to set integrated mathematics and engineering assessment." [Project Report, Mathematical Modelling and Problem Solving, University of the West of England]**

53. The mathematical modelling and problem solving project also resulted in an unexpected outcome in that its work was extended into schools and colleges through outreach activities. Ten teachers and 40 students participated in a full day workshop at the University of Manchester in conjunction with the charity Mathematics in Education and Industry (MEI), and 56 year 12 students engaged in a full day of modelling and problem solving using Newtonian mechanics at the University of Leeds. Both Universities have committed to continuing these activities, and MEI have recently been funded by Government to create a new mathematics course for sixth-form students not studying A-level mathematics focused upon using mathematics to solve real world problems.

54. While the adopting universities have implemented their activities with students for the first time within 2012/13, their progress, in terms of both impact and sustainability will be explored at a seminar to be held in Leeds in July 2013. This is the second in the series and indicates the commitment of the University of Leeds and the project lead to maintaining the active national network that has been established. It will also provide an opportunity to further integrate all project leads with the A-level work being undertaken by MEI on problem solving.

55. The Review of the Student Experience in Chemistry identified the skills of new undergraduates in the laboratory as an area for concern, and several chemistry departments engaged in activities through the programme to address this issue. The Universities of York and Surrey, both worked collaboratively on complementary activities to develop a series of videos and pre-laboratory exercises that were subsequently utilised by their first year students; a number of the resources produced were themselves developed by undergraduate students through summer internship projects:

"The videos mark a major change in existing practice within the teaching of chemistry at the University of Surrey, and such an approach has not been tried before…Inspired by the current project, other members of staff within the department have since gone on to produce similar videos for the benefit of students covering a variety of other techniques." [Project Report, Chemistry Practical Skills Podcasts, University of Surrey]

"Developing resources to support labwork in Chemistry has been a team effort in York. Academic staff identified key techniques and operations that would benefit from video resources, undergraduate project students worked with laboratory technicians to produce the videos, and teaching fellows have embedded the resources into a bespoke VLE platform to provide a coherent and growing resource. HE STEM support turned this from a niche project into one that now covers all of the crucial Year 1 transition period and is extending across higher years." [Project Report, Student Laboratory Skills at the Transition into HE Chemistry, University of York]

56. The University of Nottingham took a different approach by implementing a Practical Boot Camp which was designed to provide targeted students with a solid foundation in essential chemistry skills through four days of experimentation and one day of report writing based upon a model that had run successfully at the University of Manchester for several years:

"Responses to the initial questionnaires for students that attended boot camps run in 2010 and 2011 are typical of those received in previous years. The students indicate a widely varying perception of the sufficiency of their A-level practical lessons, and relatively few students indicate that they are satisfied that they have performed sufficient practical work. This typically equates to a lack of confidence in performing university practical work and leads to feelings of nervousness upon entering the laboratories… Pleasingly, after the boot camp, feedback shows a marked improvement in student confidence. Students universally feel that the boot camp is a useful exercise and they feel they have markedly improved their practical skills having attended... Evaluation of the students' performance once they began their undergraduate courses showed that they performed at least, equally well in their first-year laboratory courses as the overall cohort. Student retention was also excellent." [Project Report, Chemistry Practical Bootcamp, University of Manchester]

57. A further approach was undertaken at the University of Durham which redesigned its entire first year laboratory provision [Case Study 47] as part of a large scale curriculum project and undertaken by the RSC's Teacher Fellow who was based at the University. The redesign was not only undertaken to aid student transition but to produce an integrated and varied sequence of laboratory activities

with a more student centred focus with an emphasis upon developing the key skills required of graduate chemists through ‘skills, discovery, and projects’. While changes were initially only made to the first year laboratories, they have now been extended to the second year, and plans are underway to extend them to their third year laboratory course as well.

58. The computing skills of some students were also a concern for some universities where many incoming students have no prior programming experience. Within the School of Physics and Astronomy at Cardiff University, for example, work was undertaken with an emphasis upon enabling students to solve physics problems from across a range of other modules on a regular basis utilising computer based techniques. Two physics interns were appointed over the summer, and in a model similar to the SYMBΩL initiative, worked with the module organiser to produce a new first year single module course based upon 11 two hour computing laboratory classes. Staff training in the new course was provided to over 20 people, including a mixture of academic, research and support staff.

“The first year module is just the start. It will be built upon in subsequent years with a compulsory second year module and probably an optional 3rd year module. It will be embedded widely in non computing modules, starting with the practical laboratories and core modules.” [Project Report, Combining Problem Solving and Computational Skills in Physics, Cardiff University]

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59. Not mentioned so far has been the assessment of STEM Programme’s of study. As the mathematical sciences perhaps have the most traditional forms of assessment, this formed an area for particular activity with two complementary strands: assessment and feedback and eAssessment [Case Study 41], both of which have involved significant participation from within higher education institutions. An overarching project, Mapping University Mathematics Assessment Practices was undertaken by the Universities of East Anglia and Durham that not only produced a handbook of assessment practices and exemplars for departments looking to enhance their assessment practices, it supported seven departments to either trial new assessment methods, or evaluate their existing ones:

“The School of Computing and Mathematics have purchased sufficient [personal response] devices to equip the entire second year. Plymouth University has funded a Teaching Fellowship for the authors to further develop the work described here. This work will include pedagogic outputs as well as question banks developed from the material described elsewhere.” [Project Report, Mapping University Assessment Practices, Plymouth University]

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60. The project on assessment and feedback was led by Sheffield Hallam University but involved a further 12 others and aimed to help staff improve feedback to students whilst addressing the difficulties and barriers staff may face in providing the most effective feedback.

"This project was really a number of small projects; feedback changes introduced by individual staff or departments…The project was interested also in providing opportunities for staff to share their experiences and learn from others." [Project Report, Improving Feedback in HE Mathematical Courses, Sheffield Hallam University]

61. While the programme's projects on embedding eAssessment were perhaps initially focused upon the mathematical sciences, with a number of modifications to practice within mathematics and engineering taking place, the focus was broadened to include the development of an on line numeracy resource for pre-registration student nurses and midwives at the University of the West of England, and within a regional project in the North East to aid the development of mathematical skills amongst those currently within the National Heath Service workforce. Within this latter project, however, there was insufficient time to fully utilise the eAssessment tool with learners:

"The current version of the on-line assessment tool…now has the facility to be used by individuals or by tutors who can create bespoke assessments for their students if so desired. There is also a facility for students or tutors to request the results of assessments. This addition was welcomed by NHS staff within the Group." [Project Report, Mathematics Support in the National Health Service: Applying Proven Practices to Workforce Upskilling, University of Bradford]

62. Through the RSC's Teacher Fellowship scheme, assessment formed a key focus of the activities for the Teacher Fellow based at the University of Manchester. The existing policy of the School of Chemistry was not to make available mark schemes for the end of year summative examinations of first year students; following discussions of the School's Teaching Committee it was decided a pilot scheme would be initiated where some kind of model answers were released to students in their first year:

"The results of this pilot have had far reaching effects for the School of Chemistry at Manchester as it has represented a real cultural change. We have plans to extend the pilot into the use of exemplars in the Peer Assisted Study Support (PASS) scheme as well as selected modules in second year such as spectroscopy when the types of questions are new to students." [Project Report, Royal Society of Chemistry Teacher Fellowship Scheme, University of Manchester]

63. While there is a move towards alternative mechanisms of delivering the STEM disciplines within higher education, lectures remain an important component of university teaching. At the University of Southampton [Case Study 48] a series of first year chemistry lectures were recorded and made available to students online. While the project initially focused upon a sub-set of first year lectures, in its latter stages the majority of first year chemistry lectures were recorded. The evaluation of the project that was undertaken indicated that the availability of the recordings helps to facilitate a smooth transition to lecture-style delivery for the students:

"The positive response from students shows that this project has had the biggest impact on the student experience of any initiative we've implemented in recent years." [Head of Chemistry, Recorded Lectures, University of Southampton]

The Practice Transfer Adoption scheme enabled the Recorded Lectures project to be transferred to four further universities who are implementing the approach within 2012/13.

Student Engagement

64. Student engagement describes the mechanisms by which students can become directly involved in shaping their overall learning experience while at university. The Higher Education Academy[13] defines this as a spectrum of activity **"from students influencing national policy on learning and teaching, to students developing their own individual learning agendas. In between there are examples of students engaging in institutional and departmental discussion on curriculum design and delivery."** A key feature is that students are engaged as active participants, enhancing either their own learning or that of others; most importantly, student engagement extends beyond the passive involvement reasonably expected, such as attending lectures, participating in discussion groups or problem solving classes.

65. Student engagement has been a core feature of the activities of the Programme, and there are examples that map to many of the levels on the spectrum. For the activities undertaken with schools and colleges, undergraduate and postgraduate students have supported their delivery as ambassadors, but in doing so have had opportunities to develop key transferable skills. In some cases the activities have been structured to allow students to explore possible future careers:

"The day was also used as a learning experience for undergraduate students interested in a career in teaching." [Project Report, Chemistry Outreach Package, University of Exeter]

Similarly, within the mathematics support centres developed through the Programme, postgraduate tutors are frequently utilised to support undergraduate students who drop-in. Another feature of the work of **sigma** was to ensure such postgraduates were appropriately trained through a series of national workshops and resources[14].

66. Peer Assisted Learning (PAL) offers students the opportunity to support the learning of others. A common model involves providing first year students the opportunity to work with trained second year students, and this has been shown to have benefits for both the mentee and the mentor. For the mentee hearing of the experiences of their mentor during the first year can aid achievement and progression rates; for the mentor their own subject knowledge can be reinforced, they gain confidence in working with small groups and their employability is enhanced. At Bournemouth University the Peer Assisted Learning project reviewed and disseminated current practice, identified guidelines and good practice for universities wishing to implement PAL schemes[15], and conducted a pilot study relating to making peer assisted learning available online. 120 participants attended the four seminars, with the third seminar on establishing PAL schemes proving particularly popular by attracting 48 delegates.

[13] http://www.heacademy.ac.uk/assets/documents/studentengagement/supporting_doc_for_spectrum_Apr10.doc

[14] http://www.mathcentre.ac.uk/resources/uploaded/46836-tutoring-in-msc-web.pdf

[15] http://projects.hestem-sw.org.uk/upload/PAL_report.HESTEM.V1.LB1.pdf

"PAL has always been at the back of my mind but I never knew, from a central department with limited funds, how I could make this happen on an institutional level. I'll certainly be recommending this now as an option and now I have some ideas and contacts in order to move it from the back of my mind into a real business case for why I can no longer afford to not do PAL."

"An excellent day for me, even though my course is not a STEM one. I learnt a lot thank you and we shall be looking at our induction/PAL and tutoring to ensure that it balances and is complementary as well as fitting into the GROW@BU present philosophy."

Delegates, Peer Assisted Learning Workshops

67. The trialling of online PAL at the University of the West of England continues through an institutional grant, but a key outcome of the project was the establishment of four PAL schemes at the Universities of Bradford, Exeter, Liverpool and Plymouth through the Practice Transfer Adoption scheme. All Universities launched their schemes during the 2012/13 academic year, with each planning to provide support to a significant number of learners (200 first year mathematics undergraduates (Exeter), 215 students across mathematics and chemistry (Liverpool), 160 foundation and first year students in mathematics and statistics (Plymouth), and 150 first year computing students (Bradford)):

"At the time of reporting, all projects are on track. There is evidence of significant learning taking place…and it is helpful to note that this early on in the project there is also evidence of impact. All the projects have identified sustainability through institutional commitment, and there is clearly evidence that once the pilots are successfully completed and evaluated PAL will be embedded at programme level." [Project PTA Report, Peer Assisted Learning: In and Beyond the Classroom, Bournemouth University and University of Bath]

"It is hoped that if the pilot goes well then PAL could be supported centrally and expanded across the School and beyond into other Schools, using this as a suggested model in terms of its transition support focus and link to the curriculum via a timetabled module, but in each case tailoring it to best suit the needs of the students and staff in that area." [Project Report, Peer Assisted Learning: In and Beyond the Classroom, University of Bradford]

68. Student views were often sought by projects when designing activities and interventions. At the University of Bath for example, the legacy project Strengthening, Extending and Embedding Employer Engagement, discussed within Section 4, which has embedded employer engagement across the undergraduate STEM curriculum, engaged students at the outset to help design the programme:

"We instigated a Student Working Party to enable direct input from students into the programme. This resulted in the development of a session framework that can be used for future sessions to ensure that both students and employers get the best value from the programme." [Project Report, Strengthening, Extending and Embedding Employer Engagement, University of Bath]

"In addition, staff and student views were sought on how to improve the project module's delivery and link it to other units within the programme…The initial engagements were not entirely successful, but the overall delivery approach and philosophy on project generation has been changed, based on feedback received from staff and students." **[Project Report, Work-based Learning: Learning and Working Linked Through Management of Projects, Derby College]**

69. At the University of Exeter, the Student Led Employability Audit Toolkit [Case Study 38] was developed following recognition of the need for universities to develop ever greater engagement with graduate employers to ensure that the employment needs of both employers and students are met in a coordinated way by the higher education curriculum. The project facilitated collaboration between students, graduate employers (JP Morgan, Airbus, Microsoft, Royal Bank of Scotland and Teach First) and higher education staff to establish a set of criteria to enable an audit of the extent to which employability support was integrated within the University of Exeter's mathematics, computer science and engineering degree programmes. In response to the recommendations made by the student audit, changes have been made to the undergraduate curriculum:

"A mathematics group project module has been successfully rolled out in response to the student-led employability audit. This module develops some of the employability skills that students saw to be lacking in their programme such as communication, project management and team working… In addition, another Mathematics module is in development which will allow the students to act as an 'ambassador for maths' by promoting the subject in schools and assisting in the newly formed Peer Assisted Learning (PAL) scheme at Exeter. This module has also been in response to the student-led audit…" **[Project Report, Student-led Employability Audit Toolkit, University of Exeter]**

70. In another demonstration of the success of the Practice Transfer Adoption Scheme at transferring practice effectively between higher education institutions, the Student Led Employability Audit Toolkit was successfully transferred to five universities:

"In all, the transferability of this project seems to be successful as the project teams have all adapted the original Exeter project in one way or another. It has shown how initial guidance can be interpreted to suit the needs of individual adopters and of the students involved. This has been a particular highlight of this project as the adopters have managed to each produce an audit which is unique to their own programmes." **[Project PTA Report, Student-led Employability Audit Toolkit, University of Exeter]**

71. Of the adopting universities, a number have identified proposals for curriculum change following recommendations made by students. Some minor changes have already been made to programmes, while more significant major changes are undergoing serious consideration:

"…changes will not be made to the overall programme but will be made at the module level, as some missing skills were identified such as 'commercial awareness'. These are now being implanted as part of a green chemistry project on Enterprise." [Project Report, PTA Adopter of Student-led Employability Audit Toolkit, University of Bradford]

"Of the proposals that have come from this report, that for a group project will be presented to the School Teaching Committee, the extensions to the Mock Interviewer Programme and the Real Life Business Problems will be taken to the School's Careers Team and we expect that LaTex Classes and the suggested minor changes to current course units will be implemented in the 2012/13 academic year." [Project Report, PTA Adopter of Student-led Employability Audit Toolkit, University of Manchester]

72. Loughborough University's SYMBΩL, Second Year Mathematics Beyond Lectures project was highlighted earlier (Section 4) in terms of the success of its adoption by the University of Exeter [Case Study 39], and its impact upon practices across the College of Engineering, Mathematics and Physical Sciences. At Loughborough, SYMBΩL set out to address long-standing issues associated with high failure rates on some modules and disengagement amongst parts of the cohort of second-year undergraduate mathematics students. By utilising paid summer internships, during which students worked closely with staff members advising on enhancements to the modules and preparing resources, and the recruitment of 13 third year students who worked voluntarily as 'student leaders' during weekly PAL sessions with second year students, the objectives were to stimulate enthusiasm, improve engagement, satisfaction and pass rates for two second year ten credit modules.

73. The project has been a notable success on several levels. The interns who participated found their own level of understanding of the topics improved significantly as they sought new ways of communicating the mathematical ideas to their peers, and noted their relationships with staff members also improved. A detailed evaluation of the impact of the intervention is being undertaken as part of an ongoing PhD thesis and this has already noted the intervention achieved one of its objectives of increasing student performance:

"In other words, if two students with similar prior attainment and similar lecture attendance had attended different numbers of PAL sessions, it is probable that the student attending more PAL sessions would have obtained a higher examination mark." [Project Report, SYMBΩL, Loughborough University]

Perhaps most significantly, SYMBΩL implemented a new and previously untried approach within the Department of Mathematics Sciences:

"It is true to say that there have been several changes which would not have taken place without the SYMBΩL project. There had been no history of internships in the Department of Mathematical Sciences at Loughborough in which interns worked with staff on enhancing modules. No PAL scheme had ever been implemented in the Department." [Project Report, SYMBΩL, Loughborough University]

74. The SYMBΩL project has continued into 2012/13 at Loughborough with five interns working over the summer on a second year and third year module, and with the PAL scheme continuing to operate. A successful application to the Loughborough University Alumni Fund has resulted in peer support being developed in other parts of the University.

75. In a further model of peer support, the University of Greenwich had initially established a 'Maths Arcade'; the Maths Arcade provides a location for students to engage with mathematical problems, puzzles and games [Case Study 43]. It was established by the University to help encourage staff-student interaction, and to provide a mechanism for challenging the more able students while at the same time supporting those within weaker prior mathematical backgrounds. Working with the Programme enabled the Maths Arcade to be extended at the University:

"This has allowed us to run staff training sessions, purchase more games and extend our opening times to three hours per week instead of just one…The concept of the Maths Arcade has also been taken up by other departments. Currently two departments in the Business School and one in Engineering at Greenwich have started their own Maths Arcades. Schools have also expressed an interest. The University of Greenwich now has a team of STEM ambassadors who take the games and puzzles into schools to promote the ideas behind strategic thinking." [Project Report, Maths Arcade, University of Greenwich]

76. Pump priming support from the Programme also enabled the Maths Arcade to be transferred to seven further universities thereby establishing a national community of practice, and providing an opportunity for this to add value to other departmental practices:

"This is run in a weekly session…which provides students with a social outlet and a focus for the discussion of mathematics puzzles of all descriptions. This also provides a convenient backdrop to any maths open days that happen to fall on a Wednesday afternoon. In addition, the puzzles and games have been incorporated into a second year mathematics module that aims to develop problem-solving skills." [Project Report, Maths Arcade, University of Salford]

77. Imperial College London worked with Loughborough University to transfer its model of student led projects. At Imperial College London, student led extra curricula activities and projects are longstanding and varied with an estimated 200 students involved in supporting projects or project proposals in any given year to try and make a practical difference to the wider community by using their engineering knowledge. The scheme was transferred to Loughborough during the 2010/11 academic year, and approximately 45 students were involved in submitting proposals for activities for which funding was then provided for them to implement their ideas. The projects enabled students to work with a range of organisations, charities, and employers including JCB Power Systems, Rolls Royce, AstraZeneca and British Sugar.

78. A key feature of the project were the relationships that developed:

"Another unanticipated outcome of the project is the working relationships that have developed both internally at Loughborough and externally with Imperial College London… This project has grown and evolved beyond expectations, developing into further projects. Additional external sponsorship has funded ongoing activities." [Project Report, Student Led Projects, Loughborough University]

As a consequence of the developed relationship, the Student Led Projects scheme was extended further. The experience of student led projects showed that students do not always recognise the employability enhancements that their work brings to them as they are focused on the engineering outcomes rather than their personal development. In response, a student led symposia initiative was conceived as a mechanism whereby groups of students, staff and other stakeholders from within an institution or beyond would have a reason to interact and develop understanding and skills while sharing learning and helping to sustain and extend individual student led groups. Two symposia were held at Loughborough University and Imperial College London, both organised by the students themselves, with a total of 85 delegates attending

"The symposia provided students with the opportunity to disseminate their activities beyond the confines of their own project and institution. They also had the opportunity to develop working relationships with employers and staff and students from their own and other institutions… The student organising committees from Imperial and Loughborough both deemed each symposium to be successful and together set up a national student-led projects community. They held a further event in…(beyond the original aim of this project) and further events are being planned." [Project Report, Showcasing and extending student-led employer-focused extra-curricular activity, Loughborough University and Imperial College London]

79. The Practice Transfer Adopters scheme provided an opportunity for Student Led Projects to be extended more widely across the sector, and seven universities (the Universities of Birmingham, Bradford, Cumbria, Exeter, Salford, Staffordshire and the West of England) were successful in securing support. Each university implemented student led projects during 2012/13, and while full details of the impact of these projects are not yet available, there is already evidence that these have had a wider impact upon institutional practices. For example, at the University of Birmingham which implemented these through its Careers Network:

"… the EPS [Engineering and Physical Sciences] Careers Network Team (formerly CEC) have created a structure for working with 'student groups' on student-led employability events and activities…This has been particularly effective this year with a noticeable increase in levels of engagement at these student-led events." [Member of Staff, PTA Adopter of Student Led Projects, University of Birmingham]

80. In a different model of student led projects, the University of Warwick, in undertaking a review of how higher education institutions and SMEs can interact more effectively to create more opportunities for graduates, employed four undergraduate researchers over the summer months to lead the study. The students themselves determined the study's direction working as a research group, and were supported by a Research Officer, also a part-time postgraduate student, and a member of staff from the Institute for Advanced Teaching and Learning, and the Centre for Student Careers and Skills. While the report itself will provide longer-term benefit to the University of Warwick, particularly given the original project proposal was submitted by the University's Pro Vice-Chancellor for Research, Knowledge Transfer and Business Engagement, this model of student engagement also provides one the University will learn from:

"Both…HE STEM-funded projects will be presented to the University of Warwick programme strategy group where they will inform and shape the University's forthcoming employability strategy." [Project Report, Real World STEM, University of Warwick]

81. Other Programme projects are seeking to modify their developed practices further in the future to increase the level of student engagement with the activities. For example, within the School of Physics at Cardiff University, which established a series of off-site visits to allow students to see physics being applied in a non-university setting, there are plans to engage those who are perhaps less motivated in employer focused activities:

"It is planned to involve the student social society in selecting and promoting other visits next year, as it is hoped that this will lead to improved engagement with the wider student body, lasting longer into the year...It is apparent that visits which depend on students signing up, and also turning up on the day, tend to benefit the more motivated and organised members of the community. In order to reach the less motivated, a new lecture course will be delivered next year in which students will solve real problems set by organisations outside academia." [Project Report, Physics in Action Industry Visits, Cardiff University]

Revising the STEM Curriculum through Employer Engagement

82. Before implementing curriculum interventions, a number of Programme projects sought to engage with employers to better understand the skills they require of graduates. Such an approach might at first be surprising given the array of national information available on employer requirements, including further analyses produced by the Programme which sought to bring this information together[16]. However, much of the national information available is somewhat general in nature, and further work is often required to understand what the issues are within the context of the STEM disciplines and how employers would like students to effectively articulate their skills at interview stage. Additionally, in initiating dialogue it perhaps reflects the wider relationships

[16] http://www.hestem.ac.uk/sites/default/files/employability_skills_review.pdf

that universities have with particular employers or employment sectors, and as such provides an opportunity to engage these employers in teaching and learning activities:

"The project has provided a mechanism to open up dialogue with industry with a real purpose, Initially it was challenging to work out the best way to work together but as the project progressed and we could define a specific requirement, employers were very helpful" [Project Report, Engaging with Employers to Enhance Employability in Mathematics Graduates, University of Leeds]

83. At the University of Leeds, for example, an External Advisory Board was established within the School of Mathematics, and latterly an Industrial Advisory Board (IAB) in the Schools of Chemistry and Physics and Astronomy, to enable this dialogue to take place in a structured manner. The University has recommended all Schools or Faculties establish an Industrial or External Advisory Board, and the resources and learning from this project were used as a basis for establishing an IAB in another Faculty.

84. The External Advisory Board was able to advise on the development of a new module within the School of Mathematics to which employers contribute directly to its delivery:

"A year two (Level 5) 10 credit module 'Maths at Work' was trialled by the project with 35 students and has now been developed as an optional module in 2012/13 for all year 2 students…The module incorporates career development activities with employer input and the major component is a team project with topics being mostly developed in collaboration with industry. The employers gave the project authenticity and have helped to strengthen links between the school and key industries. The model for the module development is to be replicated for other STEM disciplines." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

85. At the University of Sheffield not only was an employer liaison group established that is now embedded within the structures of the Faculty to ensure sustainability, but a series of case studies were produced to aid other universities wishing to establish similar provision. The dialogue opened with employers has impacted upon the activities of the University at faculty level:

"The Faculty…is building a relationship with a group of 9 employers including HBM nCode, the Kostal Group, Peakdale Molecular, Reckitt Benckiser, Ernst and Young, RWE nPower, ITM Power and TeachFirst, all have sites or offices located in Sheffield, Derbyshire or the Yorkshire and Humber area. The participants value the mutual insight that the Employer Liaison Group has provided of the University, academics, students and employers, and generated a forum to share views on the various stakeholder needs. The resulting legacy has included the provision of bursaries, training opportunities for students, placements and course materials. Links have also been established between companies and the Careers Service to highlight opportunities to Science students with, for example, unique language abilities (Mandarin, Cantonese) and last but not least research contacts have been made between academics and companies that could ultimately benefit students through teaching." [Project Report, Creating and Embedding an Employer Liaison Group, University of Sheffield]

86. Industrial Advisory Boards have proved effective within the Programme at engaging employers in the activities of universities, and in addition to those already reported, a further eight were formally established (at the Universities of Bradford, York, Manchester, West of England, Hull, Sheffield, Hertfordshire, and Kingston) through the Practice Transfer Adoption scheme. Effective practice was shared with the adopting universities at an initial event organised by the Programme's Professional Body Partners.

87. Within Wales, a regional approach was taken to establishing an employer forum in both North (led by Bangor University) and South Wales (led by Cardif Metropolitan University). The North West Wales Employer Engagement STEM Forum provided a much needed mechanism for employers, schools, further education and higher education institutions to communicate. The forum has membership from over 25 organisations, including employers such as BT, Magnox, Scottish Power, Arriva Trains Wales, National Grid, and Royal Mail. With the forum now established, it will be sustained through continuing contributions from Business in the Community, the North and Mid Wales Reaching Wider Partnership, as well as contributions from its employer members.

88. Through engaging in early discussions with employers, the University of Leicester was able to use employer feedback to inform the design of a new final year work-related module which has so far been taken by 20 students. Through the module students experienced a series of linked activities including a business simulation game run by consultants over a period of six weeks and attended an employability workshop run by Leicester Chamber of Commerce. In the second semester, each student spent around 100 hours working on a 'real world' project that had been proposed by an employer (Northamptonshire Police, Clockwise Credit Union, Commsave, Apical, Alstom, Eon, Vichag Ltd., Imagination Technologies and the University of Leicester). The employers took part in the judging of final presentations and also 'speed-dated' with the students resulting in an offer of an internship and a job.

89. The success of the intervention has stimulated some wider developments at the University. An Employability Forum was held in conjunction with the University's Careers Service, which invited external organisations to receive presentations from students who described the benefits to them of employer related projects and explored how they might engage with curriculum development. The model is seen as an example of good practice and the Careers Service intends to offer it to other departments. In addition, there have been further benefits for cross College working:

"…there have been outcomes we never expected; the project ballooned because the hunger from employers for real engagement has proven to be large…[In addition a] College Employability Group was formed during the project, with a representative from each department. Through this group we are now exploring the idea of a shared business game module for mathematicians and engineers, a shared employer-related module with Physics and Geography, a day at work for all first year students in the college, and other college related activities. Because of the setting up of this group the college invested in an employability intern who has carried out a number of activities across the college..." [Project Report, Identifying the Skills Gap for Employers and Mathematics Undergraduates]

Both Nottingham Trent and the University of Birmingham have also utilised a similar approach to develop their provision in mathematics [Case Study 40]. In addition, Nottingham Trent worked closely with Leicester on its curriculum developments.

90. In developing the Programme's Large Scale Curriculum Projects three universities (the Universities of Sheffield Hallam, Loughborough and London Metropolitan) each submitted proposals to implement similar activities, namely to develop their curricula to better teach appropriate skills for professional engineering practice. Further, the individual proposals were each based around developing support for inter- or multi-disciplinary assignment, laboratory and practical work. The decision was taken to bring the three individual projects together and create a larger collaborative project to enable learning and ideas to be shared:

"…dissemination of this learning between the partners meant that we were able to trial and test a rounded implementation in each institution involving academic taught material, practical lab based project work, together with an appropriate support structure for operation across a range of undergraduate courses." [Project Report, Education for Professional Engineering Practice, Sheffield Hallam University, Loughborough University and London Metropolitan University]

91. Sheffield Hallam University introduced interdisciplinary assignment work across a large group of first year students on eight different engineering courses who were undertaking a joint module. 143 students from eight different Bachelors level engineering courses worked in multi-disciplinary teams on inter-disciplinary problems based around the Engineers without Border Challenge which uses real world problems experienced in developing countries as a vehicle for students to explore suitable solutions. The module was supported with 48 hours of traditional lectures, tutorials and laboratory sessions, and as part of the implementation, students were required to compile an individual portfolio of progress with their projects and to interact with a reflective on-line blog.

92. The CADubator project was also established at Sheffield Hallam University as part of the initiative. Undergraduate students are now running a small company undertaking Computer Aided Design (CAD) work for local businesses:

"…a global participating company has offered [Amount Removed] sponsorship of the 'CADubator' programme plus a student placement next year. We now have two more projects from the company for students next year." [Project Report, Education for Professional Engineering Practice, Sheffield Hallam University, Loughborough University and London Metropolitan University]

93. At Loughborough University the project was based within the School of Electronic, Electrical and Systems Engineering where there were two main types of multi-disciplinary projects for which the support system was developed and implemented a mentoring system where fourth year (level 7) mentors provide support for mentees from level 5; and, peer support and peer assessment in various forms in all group work. At London South Bank University:

"London South Bank University has dramatically changed the way it delivers its curriculum to first year (level 4) engineering...One aspect of this change has been the introduction of project work forming a part of a module called Design and Practice. Other skills developed in the module include communications and drawing skills and laboratory work." [Project Report, Education for Professional Engineering Practice, Sheffield Hallam University, Loughborough University and London Metropolitan University]

94. All three Universities have reported that the developments have had positive impacts, and that as a consequence the interventions will be sustainable. For example, at Loughborough University two undergraduate interns are undertaking the next stage of development. The three Universities have also indicated they will continue to collaborate in sharing developing practice, and will be bidding as a collaborative partnership for future funding opportunities.

"Feedback from students at Loughborough indicates the multi-disciplinary reforms described are allowing students to engage with professional engineering practice. For example students completing one of the third year projects have commented that they feel like they are acting in 'a more professional way', almost like they are 'already working in industry' and that they understand how their discipline 'may be implemented in the real world'…Staff feedback on the SHU EWB level 4 curriculum reform suggests that working on a real world situation that has the potential to have a positive impact on others' lives has had a major influence on student engagement with the activity and the associated module; especially attendance which has been double that of previous years...In reflective feedback, LSBU students generally note higher skills development in the project based work than in other aspects of the module…" [Project Report Education for Professional Engineering Practice, Sheffield Hallam University, Loughborough University and London Metropolitan University]

95. The developments at Sheffield Hallam used ePortfolios as a means of engaging students to reflect upon their learning experience, similarly the University of Bradford made its institutional ePortfolio tool available to staff and students, with a view to supporting their experience of final year engineering projects. ePortfolios also provide a means for students to reflect upon, and record, their progress towards developing key employability skills which can prove to be particularly helpful when they begin to apply for graduate jobs. At Nottingham Trent, where significant revisions to the curriculum within chemistry, physics, forensic science and computing were undertaken through a project that coincided with an unexpected University wide curriculum review, skills portfolios are now used within assessment contributing to wider reforms implemented in collaboration with employers:

"Skills portfolios are now key assessment types in a range of programmes e.g. physics are now using them in 5 year 1 & 2 modules. In 2012-13 portfolios are expected to become a significant part of courses in chemistry, physics, forensics and computing to sit alongside the original bioscience model and further development are underway in sport sciences." [Project Report, Building Effective STEM Graduates, Nottingham Trent University]

"The Nottingham Trent University project worked closely with employers to introduce new approaches to practical work, develop an evidence-based skills portfolio for graduates to articulate evidence of their practical/professional skills, and included context based/ problem based learning activities into modules in chemistry, physics and forensics using professional/industrial contexts/case studies. The project has worked with Biocity in Nottingham and set up workshop and events where lab managers and employers of STEM graduates could review the skills sets devised and feedback on issues. The changes are becoming a significant part of a whole curriculum review." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

96. Perhaps one issue that exists with an institutional skills ePortfolio is that it may not be possible once students graduate for them to update or even access it. The RSC has developed an online version of its Undergraduate Skills Record[17], a paper resource which has been used extensively by higher education institutions for over ten years as part of their curricula to help students record their skills development. Many institutions have embedded this resource as part of their assessment which will ensure high engagement from students.

[17] http://www.rsc.org/Education/HEstudents/usr/index.asp

97. The Undergraduate Skills Record is integrated as part of the RSC's professional development programme. As part of this, the RSC recognised issues associated with the business and commercial awareness skills of STEM graduates and in response commissioned five universities to develop, and implement, resources for teaching contextualised and relevant business skills to chemists for integration into the chemistry curriculum. Through the development of the Business Skills resources, the participating higher education institutions (the Universities of Leeds, Nottingham, Edinburgh, York and Warwick) built extensive relationships with external employers (including Croda, Boots, Lubrizol, Mewburn Ellis, Syngenta, Proctor and Gamble, Sasol, and Afton Chemicals) who provided case studies and insight that aided the production of the resources.

98. While the developed resources have now been made freely available to higher education institutions all over the world[18], the Universities of Warwick and York are exploring how the resources they developed might be integrated as part of their undergraduate curricula. At the University of Nottingham, the resources have already been integrated through the development of a new module:

"The course will be embedded within the curriculum at Nottingham starting in October 2012. It is credit bearing and targeted at 3rd and 4th year Chemistry students." [Project Report, Business Skills for Chemists, University of Nottingham]

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99. While at the University of Leeds funding has been secured for further developments in Chemistry that were stimulated by the employability project within the School of Mathematics discussed earlier:

"This, in turn, has led to a major HE Academy funded project (£60k) to develop a further level 3 module; Chemistry: Making a Difference (social enterprise business start-up module, with a chemistry focus). There is also interest in the Faculty of Biological Science at Leeds to develop a module along the same theme… It is no exaggeration to say that all of these developments were as a result of the initial Maths HE STEM project." [Project Report, Engaging with Employers to Enhance Employability in Mathematics Graduates, University of Leeds]

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100. At Cardiff University a project was undertaken with a view to developing more employable STEM graduates by advancing students' commercial awareness and enterprise skills through the piloting of a free standing accredited module within the undergraduate curriculum. The module, developed and delivered by local employers and entrepreneurs, was created using a flexible framework which meant that it could either be delivered as a full 10 credit course, or components could be delivered as stand alone teaching sessions. The module is based around an experiential learning scenario in which learners engage in the simulated 'commercialisation' of a discipline-specific innovation and associated company development. Students approach active learning tasks working in teams, and real world discipline or sector specific examples are communicated to students by external speakers or through the use of case studies.

101. This 'Commercialising Innovation' module was offered in full as an option to third year students from electrical engineering, and there are plans for this to also be offered to students from mechanical engineering and biosciences from 2012/13. Components of the developed enterprise teaching were also delivered within existing modules within the Schools of Mathematics and Chemistry; in

[18] http://www.rsc.org/learn-chemistry/collections/higher-education/he-resources/business-skills-resources

total 220 STEM students participated in the developed intervention. A significant outcome is the role of the project in influencing wider institutional practice:

"As of September 2012 it is hoped the institution's employability and enterprise strategy will assert the development of curriculum embedded employability and enterprise skills development, while advocating the implementation of specific modules designed to develop learning in these fields. This strategic decision has in part has been influenced by the success and resultant experience the HESTEM project has delivered. The success of the HESTEM project has enabled the institution to justify, support and win a bid for HEFCW funding under the 'Driving Enterprise and Innovation in the Cardiff City-region' project. The HEFCW funding will enable the creation of two enterprise curriculum development posts with the intention of embedding enterprise learning within the curricula of thirteen academic schools by 2014." [Project Report, Developing Enterprising STEM Graduates, Cardiff University]

102. An approach to embed multidisciplinary design and enterprise (Engineering by Design) within the curriculum of five collaborating Schools (Engineering, Business, Product Design, Creative Studies and Media, and Psychology) at Bangor University has proved equally successful. Utilising a range of internal and external expertise, a ten week programme of three hour workshops, presentations and a review, 48 students came together from different disciplines to collaborate, design and propose a range of innovative solutions to a challenge set by a commercial partner.

103. In addition to the methods developed being included in the University's Strategic Plan, an outline plan has been drafted to expand delivery to 300 students by 2015 and an Interdisciplinary Masters course is being developed. Further, funding has been secured to expand the project into new areas beyond the undergraduate curriculum:

"A successful application has been made to the Esmee Fairbairn Foundation, based on EbD. It will see a community officer included within the EbD program, a form of which will be developed for and delivered to those not in employment or education. Trustees approved funding of £145,049 over three years towards the NEET2Work programme…A successful application has been made to the intereg IV – North West Europe, programme. It will see the approach taken by EbD applied in conjunction with the NESTA Creative Startup Toolkit to support the growth of High Potential Start Ups in the NW Europe region." [Project Report, Enterprise by Design, Bangor University]

104. At the University of Bradford, the Greening STEM Legacy Project [Case Study 54] took an institutional approach to curriculum change by integrating sustainable developments into a range of STEM curricula and promoting improved environmental performance in STEM infrastructure. The project was developed to meet growing employer demand for graduates who have the knowledge and flexible skills required to develop the industries that support a low carbon future. In particular it targeted industries such as low carbon vehicle design and build, sustainable construction, green chemistry and digital technologies.

105. New modules in Human Power Vehicle Design and Build and curriculum changes in Software Engineering and Low-carbon Computing have been implemented that address the relationship between sustainable development and computing, involve active group learning between students

and staff, allow students to access digital lectures, and encourage them to think about and address the relationship between computing and sustainable development; a number of new green chemistry practical experiments have been introduced into the existing curriculum. Multidisciplinary components have also been embedded; for example, the Automotive Engineering module is a multidisciplinary, practical curriculum project which gives students the opportunity to work collectively to build a 'green vehicle' in order that a national green racing competition can be launched.

106. There are many instances within the Programme of employers informing curriculum developments or contributing components of delivery at a module level. While this in itself is a significant success as the practices of the higher education STEM community have been moved forward, particularly in disciplines where there was not previously a strong culture of employer engagement. There are also, however, instances where employers have made more substantial contributions to STEM delivery, including assessment, across entire programmes of study, or through modules that are 'owned' by the employers themselves.

107. At the University of Lincoln [Case Study 51] a new School of Engineering had recently been established with the objective of providing graduates who are ready and fully prepared to make a contribution to their future employers from their first day of employment. The project provided the University with the opportunity to build upon the partnership it was establishing with Siemens and to engage with other local employers. It implemented a series of industrially led 'touch-points' which differ from, for example, industry sponsored projects that are localised within selected project based modules, as they extend throughout the entire degree syllabus.

108. In collaboration, members of the University's academic staff and employers jointly identified essential professional skills, and then mapped these to locations within the syllabus where industry based engineers could deliver a teaching and learning opportunity to help develop these skills. Representatives from industry delivered elements of the course ranging from discrete daylong activities to a whole module throughout the academic year. One of the outcomes from this work is that the final year project has been extended from 30 to 45 credits to allow students to deliver outputs that offer real value to the company and gain credits. The involvement of employers has now begun to permeate the entire degree syllabus and is not just limited to isolated project-based modules.

"We have developed deeper and more open relationships with industry and have a better understanding of what employers mean by 'employability as opposed to what academics think it means'" [Project Report, Developing Graduate Employability Skills Through Industry Led Touch Points, University of Lincoln]

109. At the University of Teeside industrial partners worked in collaboration with academic members of staff to design and deliver specific modules which related to their core area of business. This

approach allows industry to make an upfront investment to tailor the design and delivery of a specific module to meet their needs; and the subsequent badging of these modules as 'company sponsored' demonstrates their commitment to ensuring quality of delivery. Three such modules were developed in civil engineering (BAM Nuttall), chemical engineering (SABIC) and project management (Jacobs Engineering); all three companies were large multinational organisations that are significant UK graduate recruiters, and as such had a wide range of experience and material upon which they could draw to support design and delivery.

"This approach to engaging industry/employers in the design and delivery of our curriculum will be embedded in future occurrences of these modules and extended to include other modules and disciplines…The school's operation of an external advisory board, which meets regularly with the school's senior management team, has been critical to this development as it permitted a route via which industrial partners could be recruited." [Project Report, Industrially Owned Modules for HE, Teesside University]

Placements, Experiential learning and Projects

110. The 2012 'Review of Business–University Collaboration' (the 'Wilson Review') made explicit reference to the role of placements: **"placements, internships and other work experience are extremely valuable to students, both in terms of their academic performance and their employability skills"**. The Review also highlighted that integrated opportunities for work experience can exist in a programme of study in a variety of different forms. Higher education institutions have been increasingly exploring opportunities for enabling students to gain relevant work experience to assist with their skills development and career planning.

111. While many of the STEM disciplines have a tradition of offering long placements to their students, through a dedicated year in industry for example ('sandwich placements'), there are limits on how many longer placements can be made available to students. In addition, the Wilson Review itself noted a decline in the number of students choosing sandwich placements over the last ten years, with 70% of placements now provided by only 20 higher education institutions. The alternative of shorter placements may be considered, however the quality and effectiveness of different experiences vary and it remains unclear how beneficial these are to the learners themselves or their employers; there are also practical challenges with embedding such placements into the university curriculum. The Programme sought to support this area of activity through a range of mechanisms including enabling a number of higher education institutions to explore the different opportunities for students to gain related work experience as part of their programmes of study.

112. The Legacy Project at the University of Bath reviewed existing placements with a view to developing further relationships with employers, identifying and building upon good practice, and in doing so enhancing the quality of the student placement experience. A particular emphasis was also placed upon improving access to placement opportunities for STEM students, particularly those with disabilities, by developing ways of supporting them appropriately throughout the placements and enhancing their employability skills. A general challenge with placements is evaluating whether a placement has offered a high quality experience to the student, and if it has not, understanding the reasons for this. A strand of the Legacy Project therefore developed guidelines and offered staff development sessions to help staff evaluate placement learning:

"The guidance documents will sit alongside and support University QA documents, for use by all staff (particularly placement-related) from 2012/13." [Project Report, Strengthening, Extending and Embedding Employer Engagement, University of Bath]

The Legacy Project also introduced more 'real world' experiential learning for students that ran alongside their main programme of study. This was previously discussed in Section 4, but employers contributed to student learning through collaborative projects.

113. Legacy Projects were established to exert a wider influence upon the practices of the University, and there is evidence of this being achieved at the University of Bath. The project has informed the University's 'Placements – Business Process Review[19]', and fed into the newly formed Careers & Employability Subcommittee of the University Learning & Teaching Quality Committee, which was established to ensure that employability considerations feed directly into the University's governance structure.

114. The University of Northumbria reviewed a range of placement options for chemistry students and they have developed a package of alternative approaches that are now working to support employability development. They had identified the skills set that employers say they require and knew these could be achieved through work experience but their current sandwich course did not meet all student needs. An alternative approach was to have shorter placements but employers showed a lack of interest in the model as 2-3 months was not considered sufficient time for an employer to recoup investment from the training/workplace integration required for any new employee. An alternative and additional approach has been to develop agreements for students to undertake on-site visits to employers. The project team has used alumni at the site visit where possible to correlate their own HE experience and the work they are doing in the company, to the undergraduate. The project has also developed a series of supportive workshops as a co-curricula programme, 'Job Ready', which comprises a series of voluntary attendance lectures, events and supporting materials designed to raise student's awareness of their own skills and those that are valued by an employer.

115. At Northumbria University, recognising the limited availability of year long paid placements, enquiries were made with employers as to the feasibility of shorter placements which could be undertaken within the summer break between academic years. Such an approach, however, was not welcomed by the employers as it was felt to offer insufficient time to obtain value after the necessary first few weeks of training and workplace integration. Instead, a 'Job Ready' programme, developed collaboratively with the North East of England Process Industry Cluster (NEPIC) and the University's Employment and Careers Service amongst others, of extra-curricula learning opportunities for students in their second and third years was implemented. While 42 students initially signed up to the Job Ready Programme, 70 students engaged with the programme representing a two-thirds uptake by eligible students.

19 http://www.bath.ac.uk/news/2012/02/15/placements-business-process-review/

"One unintended outcome of the project has been noted, through unsolicited informal feedback from Placement Officers, about the increased quality of applications and CV's submitted for students applying for placement positions and that all of the students that successfully obtained a year-long placement for next year were participants of 'Job Ready'…The School of Life Sciences will continue with this project's development and roll out a series of employability activities across the entire school. Employability will be further integrated into the curriculum as core curricula activities and the potential to develop an 'Employability' module bearing University credit will be investigated for the academic year 2013/14." [Project Report, Can the Employability of Undergraduates be Enhanced Through Raising Curriculum Content Awareness and Relevance in the Workplace?, Northumbria University]

116. Other National HE STEM Programme projects have also sought to address the issue of understanding what works for students and employers with regard to work experiences and an exploration of the different models work experience can take. The University of Brighton sought to gain an understanding of some of the issues associated with placements in preparation for the introduction of a university-wide accredited placement scheme. The research involved surveying over 400 students and a range of employers with whom placements were likely to be sought. In undertaking the survey it helped the University gain insight into, and information about, the current undergraduate placement scheme and has helped inform its future approach; in particular, all employers who responded indicated they favoured placements of between nine and 12 months duration.

117. In response to the study, internal proposals have been put forward for variety of accredited placement offerings in addition to the current 12 month option consisting of summer internships, shorter placement options, and flexible placement models; this latter option includes a series of shorter placements that combine to fulfil a year-long placement.

"The project results have formed the basis for proposals to be made to the Faculty Board regarding placement model offerings going forward…On a long-term basis it has highlighted the importance of gaining student and employer feedback on placement offerings and support, and as a sustainable development following the project we will look to gain feedback from both groups at the end of each placement cycle. These findings will help make the placement process robust and enable longer-term sustainable changes." [Project Report, Undergraduate Placements: Smoothing the Transition from Education into the Workforce, University of Brighton]

118. Two projects at the University of Reading were also focused around placements; the first sought to meet the requirement for better student information and preparation for placements. A previous HEFCE funded Economic Challenge Investment Fund (ECIF) project to support graduate internships in the biopharmaceutical industries had shown that graduates were not sufficiently familiar with the industry environment, and the project sought to address this gap. It was undertaken as a collaborative activity, involving other members of the regional Biopharma Skills Consortium (the Universities of Brighton, Kent, Portsmouth, Surrey, Open University and the Royal Veterinary College), and developed a website[20], that will be maintained and developed by the Consortium, containing a range of resources to help students better prepare for placements, stimulate students to research about the industry and provide information and careers advice using audio material utilising industry representatives describing their work.

[20] http://www.bsc-biopharma.org.uk/placements/overview

119. The second placements project within the Department of Mathematics at the University of Reading also undertook research to identify placement formats that would work within the context of the University's current position and that could be evaluated against the employability skills they might provide. The project then initiated a pilot amongst its undergraduate students to trial seven of the different placement formats identified. In total 17 students participated in 39 placement experiences which were then analysed and indicated that year-long placements were considered the most beneficial format for skills. One-day site visits and work shadowing were shown to influence career choice, appealed to students concerned about workload and engaged those who did not want placements. All formats were perceived as valuable when combined with pre-placement support, opportunities for self-reflection and skills awareness.

120. As a consequence, there have been changes to the Department's placement provision:

"The Mathematics & Statistics Department has introduced an optional 1-year sandwich placement for all Mathematics & Statistics students at the end of their 2nd year. Choosing this placement format supports the findings of this project that a 1 year sandwich placement has the most impact on developing employability skills. An option credit-bearing module is likely to be introduced in the final year to include a self-reflective diary, project assignment and presentation." [Project Report, Workplacements for Maths and Stats Undergraduates, University of Reading]

121. The Mathematics Department at Reading has also recently appointed a Placement Officer on a three-year contract to continue the work, and support a wider group of students. An additional outcome of the project was a Toolkit[21] for academics to support the establishment of credit bearing placements. Through the Programme Cardiff University also developed a Placements Toolkit[22], and while this might at first be seen as one of the few examples of duplication of effort within the Programme, there are a number of differences in their content. For example, the Cardiff University developed version contains a number of institutionally specific templates, and makes reference to Cardiff policies and codes of practice. Additionally, it might be argued that when implementing an intervention that is potentially as complex as placements, researching and documenting learning in a systematic manner can aid both personal development and ensure the existence of an institutional specific resource that may help aid longer-term sustainability.

"Initially I would have found it useful to have more info in the guides, in terms of the possible answers. However, the lack of detail forced me to research the topics on the internet, which meant that I learned more about the process." [Academic Member of Staff, Context and Problem Based Learning, University of the West of Scotland]

122. There are also instances within the Programme of placements becoming more widely embedded as part of an institution's practice where this perhaps wasn't one of the main original objectives:

[21] http://www.hestem.ac.uk/sites/default/files/a_toolkit_for_setting_up_credit-bearing_placements.pdf

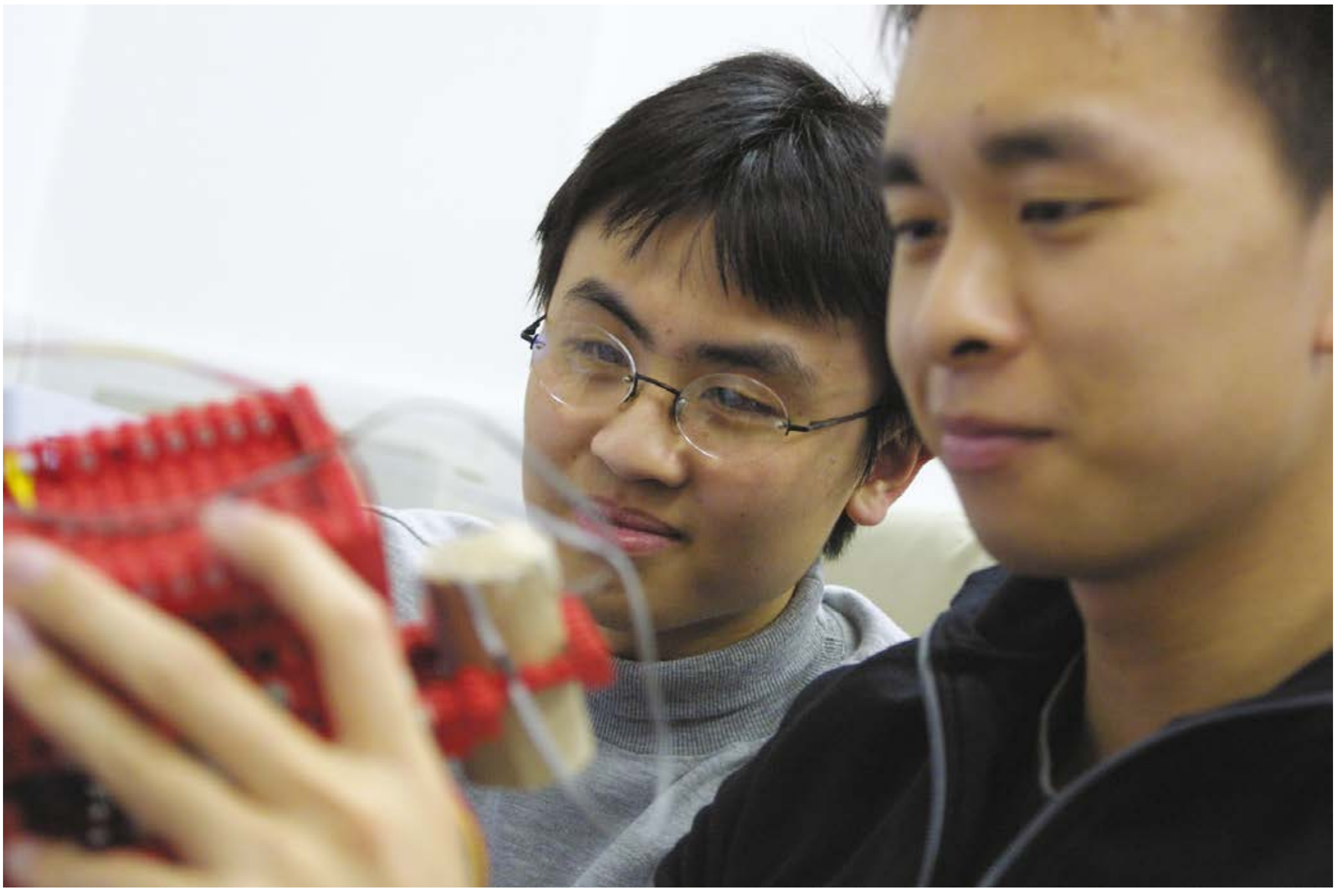
[22] http://www.wimcs.ac.uk/document_repository/Graduate%20Skills/Cardiff%20Placements%20Toolkit/Cardiff%20Placement%20Toolkit.pdf

"One specific change was that our planned module to give academic credit for undergraduate researchers at year 1/2 Introduction to Organic Research became part of a much larger movement to give academic credit to a wide range of shorter term work-based learning experiences, e.g. shorter placements, internships, live projects for industry/community groups and students acting as junior researchers. SST [School of Science & technology] developed a school wide model for modules which accredit these outcomes. In our new programmes, these appear as professional practice or professional development modules. Our aim is to build on this development so that within a few years every SST student will had the opportunity to undertake (and receive academic credit for) a work-based learning experience." [Project Report, Building Effective STEM Graduates, Nottingham Trent University]

123. For students, and indeed universities themselves, identifying appropriate placement opportunities can be a significant challenge; equally, employers wishing to offer placement opportunities don't always know who to contact within universities. The RSC organised a STEM focused event that brought staff together from over 20 higher education institutions to raise the profile of placements, share good practice, and provide a mechanism of supporting practitioners; a good practice guide to industrial placements was also developed[23].

124. To help improve communication relating to placement opportunities, the RSC now hosts a list of placement coordinators within higher education institutions, and Chemistryworld jobs now has a placements and internships page where employers can promote available opportunities. Similarly, the BizzUP and STEMBUG Gateways have a searchable mechanism for the identification and promotion of placement opportunities.

[23] http://www.rsc.org/learn-chemistry/resource/res00000951/hosting-industrial-placements-in-chemistry



125. Placements provide only one model of students gaining appropriate work related experience, and with employers perhaps favouring longer placements over shorter ones, the Programme has helped universities explore new approaches to enabling their students to obtain appropriate work related experience. The University of Birmingham's Grand Challenge Legacy Project [Case Study 53], the Imperial College and Cogent Sector Sills Council led Nuclear Island [Case Study 52], and the IoPs' Industrial Group projects [Case Study 36] are all notable examples.

126. The Industrial Group Projects were first mentioned in Section 4. They form team-based research projects with external industrial or commercial partners in undergraduate physics courses. Implementation of the scheme has varied from one institution to another, however to date it has always involved third year undergraduates undertaking the projects. Participating students work in small groups, and the completion of the project is a major component of their work for the year, typically in the range of 15 – 30 credits and 60 – 120 hours of work time per student. In the various higher education institutions in which it has been introduced, the scheme is usually offered as an alternative to an established research project option that is either conducted by students either individually or in pairs.

"The students successfully modified their behaviour so that they could work as an interdependent team rather than as a group of individuals. This should not be understated as it is a significant enabling competency for their future careers." [Academic member of Staff, Industrial Group Projects, University College London]

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127. The Industrial Group Projects initiative has proved a success so far with 19 departments now running the scheme with undergraduates. One of the challenges faced by the participating universities is that they have typically experienced more difficulty than anticipated in encouraging students to sign-up. In all institutions, however, participation has improved in the subsequent year as students learn about the benefits of the course option from previous participants. Employers, however, have proved more than willing to participate in the scheme:

"I think that the Industrial Project scheme is a great initiative, allowing students to work on and contribute towards 'real life problems'. Equally for industry, it allows us to have fresh eyes on the problem tackling it from a different perspective. It also gives us the excuse to look into all those "nice to do" topics, that are hard for us to find the time to address, or that in a more office based environment, are hard to look at." Magnet Engineer, Siemens Magnetic Technology

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"There has been considerable interest in the concept from a variety of potential project sponsors. It is clear that the module is meeting the original aims of the Institute of Physics and that in addition to preparing students for a wide range of careers the module has the potential to foster close links between the physics department and commercial and public sector organizations." [Academic Member of Staff, Industrial Group Projects, University of Liverpool]

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128. At London South Bank University undergraduate projects were used as a means of engaging SMEs with the activities of higher education institutions to develop relationships. The scheme presented a variation of the Higher Apprenticeship model, offering employers the opportunity to work with

undergraduate engineering students on short-term projects whilst training (for the SMEs) was undertaken through a university led programme of activities. Four SMEs participated in the initial pilot, and the second cycle of students engagements are underway:

"It has been observed that there is a marked difference in the approach of the returning students when compared to their peers. Their experiences have had a positive influence on the second cohort who now consider this an ideal way to gain experience without impacting on the overall length of their study programme." [Project Report, Higher (University) Apprenticeships in Engineering technology: SME Employer Model, London South Bank University]

129. Nuclear Island started as a small scale collaborative project (Designing the Nuclear Island) that built upon good practice identified in RAEng reports and created the framework for a simulated problem-based learning experience for undergraduate civil engineering students for nuclear new build based on the proven 'Constructionarium' initiative. Building the Nuclear Island was an extension of this original project, and is underpinned by collaboration between a university, a contractor and a consultant with an emphasis upon not only developing graduate skills, but preparing students for careers within the nuclear workplace. Students work in teams on a construction site for a full week to deliver a full build programme for the nuclear sector; in doing so they work in partnership with employees and apprentices developing a range of employability and hands-on practical skills and gaining experience of a construction site.

130. In addition to the work on site, students undertake a range of pre- and post build activities to consolidate theoretical learning and further enhance their skills. For example, one activity involves students undertaking a mock 'public consultation' where they act as engineers, local residents, and protestors to gain an insight into the concerns and arguments they may face if entering the nuclear industry. In addition, they interact with employers and employees from the nuclear industry and view video clips of high profile individuals working within the nuclear sector so that they can evaluate and understand the realities of the industry.

131. The first onsite Nuclear Island pilot was undertaken by 25 students from Imperial College London in June 2011. Not only does the project continue at Imperial College, but Cogent has secured additional funding from the UKCES to sustain the national programme until March 2014 and expand it to include learning packages for other disciplines and for apprentices and employees.

"The Imperial/Cogent project, 'Building the Nuclear Island' involved the 'nuclearisation' of traditional engineering disciplines. Because this involved developing a set of behaviours and attitudes rather than specific skills it necessitated curriculum development and pedagogic transpositions. This was a new approach to studying mainstream engineering rather than the development of a new sub-discipline. The undergraduate curriculum reflects this, and the post-graduate experience has changed." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

132. The University of Birmingham's Grand Challenge Legacy Project also provided an opportunity for students to work with employers on a substantial project, however, this took place outside of their formal programme of study; as such, it was non credit bearing and occurred just after the end of the summer term. This approach was deliberately adopted because it meant that groups of students

could tackle 'real world' problems in interdisciplinary teams as timetabling constraints were no longer a problem. It also meant that a full four-week programme of activity could be implemented, mirroring full-time working, and simulating the challenges of the workplace in terms of managing and prioritising multiple tasks and meeting deadlines.

133. Employers were involved in the design of the four-week programme, but also delivered a number of the sessions to add expertise in particular areas and ensure the overall programme had industrial relevance. The employer involvement happened over a short period of time, and while it was intensive, the model proved attractive to employers as it provided the opportunity for them to test ideas with individuals who might become future employees. Recent University alumni were also contacted to participate in the project, either offering workshop sessions, or providing mentoring to the students, and were used as models to help those graduates not in employment further develop their skills.

134. Over the two years (2011 and 2012) in which the Grand Challenge has run so far, a total of 78 third and fourth year students have participated from eight of the University of Birmingham's Academic Schools. In both years the Grand Challenge was oversubscribed, and in 2012, students from Aston University also participated in the Birmingham Challenge prior to the University implementing it itself within 2013. The Grand Challenge has also run at Nottingham Trent University in December 2012 as part of its employability skills module.

Careers Advice and Guidance

135. The activities discussed so far within this section have been designed to enhance student employability, and their understanding of it, provide experiential learning opportunities, and encourage students to explore how they can influence and manage their future careers. A further area where the Programme has been active is around the provision of information, advice and guidance relating to graduate careers and opportunities. For many of the projects careers was an embedded, and often non-explicit component, but a key feature of many of the Programme's employability focused activities is the way in which they have interacted, to some extent, with their institutional careers services or networks.

136. For explicit Programme activities relating to careers, the majority have focused upon providing professional development opportunities. In Section 4 the work of the STEM Careers Practice Transfer Partnership was discussed along with the STEM Careers Module which, while aimed at those providing careers information, advice and guidance outside of the university sector, is accessible as an accredited postgraduate level qualification. In Section 5 the gender and diversity workshops for careers professionals were also highlighted.

137. At Liverpool John Moores University, the Big Question project was established to initiate a dialogue with higher education careers services to understand the extent of support provided to the STEM disciplines, the extent to which STEM students engage with careers services, and the factors that influence their careers choices while in university study. In addition to conducting research with careers service personnel, students, STEM graduates, SMEs and larger employers were also consulted.

138. The research undertaken provides new insight not previously available. For example, it highlights that STEM graduates often do not participate in careers activities because of timetabling pressures, the fact that academics in departments are generally reluctant to engage in careers centred activity, and the lack of placements and internships mean students are not motivated to explore careers for themselves earlier in their undergraduate programmes. The report also indicated that much of the careers information available to STEM students is provided by the professional bodies rather than

companies themselves, and a significant issue appears to be that students do not understand the opportunities available working within SMEs. Finally, students are attracted to employers offering specific graduate training schemes, and while career progression and the geographical location of employers are important, most STEM students want to work in a STEM related job.

139. When the work was disseminated in the North West, careers advisors identified a need for access to current labour market information relating to STEM based graduate employment within the region, and the direction for future activity is clear:

> **"A strong guide was received from the participants to develop useful labour market information from across the region with specific attention on trends within STEM industry and occupations. This work is currently underway in conjunction with the LEPs [Local Enterprise Partnerships] and COGENT." [Project Report, The Big Question, Liverpool John Moores University]**

> **"The good news is that not only is there overwhelming commitment to progressing into STEM employment by graduates, this is reciprocated by the goodwill and enthusiasm of the employers to work with HEIs to ensure the system improves. The next stage is to methodically identify the key areas of disjunction between graduate and employers and to propose methodologies to overcome these barriers and miss-understandings." [Project Report, The Big Question, Liverpool John Moores University]**

140. An increasingly popular approach to providing relevant professional advice is for higher education institutions to 'link' students with business-based mentors to allow them to explore employer requirements and to network directly with people based in industry. The University of Huddersfield's Succeeding in Tomorrow's Engineering World of Work project discussed in Section 4 not only linked students with industrial mentors but also developed an internal mentoring programme designed to enhance the skills and understanding of the mentors undertaking the activity; this received university level credits and so provided opportunities for the professional development of those within the workplace.

141. At Sheffield Hallam University there was a specific focus on developing relationships with employers as career mentors for engineering and mathematics students. By being introduced to a mentor who was a professional from industry and in a role or organisation that was of interest to the student, individual students were given the opportunity to gain support in career planning by creating a network of contacts, develop an enhanced understanding of job roles, explore how

their studies relate to the workplace as well as developing interpersonal skills and confidence. A particular feature of the scheme was that it was designed to support those students deemed to have potential problems obtaining employment due to, for example, ethnicity or gender.

142. While there were some initial challenges in establishing the scheme, not least encouraging student participation and identifying appropriate mentors, 22 students were introduced to mentors. While the University had a 'pool' of over a hundred mentors, 27 professionals from a range of careers allied to mathematics and engineering were recruited and volunteered their time to work with a student. An evaluation of the scheme demonstrated that the pilot has proved effective, especially with participating students who have identified improved understanding about employability and career management, and with mentors who have recognised the advantage in having a better understanding of the students.

"It was identified that to ensure this pilot of the scheme was sustainable and became embedded within general practice it needed to be integrated within the 'student journey' so it was clear for all parties to see where the scheme fitted within a bigger framework and context of other activity both within their course and university…Sustainability beyond the course or faculty structure was also secured when mentoring was written into the University's Access Statement as a means whereby student from diverse backgrounds could be offered additional employability support." [Project Report, Developing Employer Engagement in STEM Through Career Mentoring, Sheffield Hallam University]

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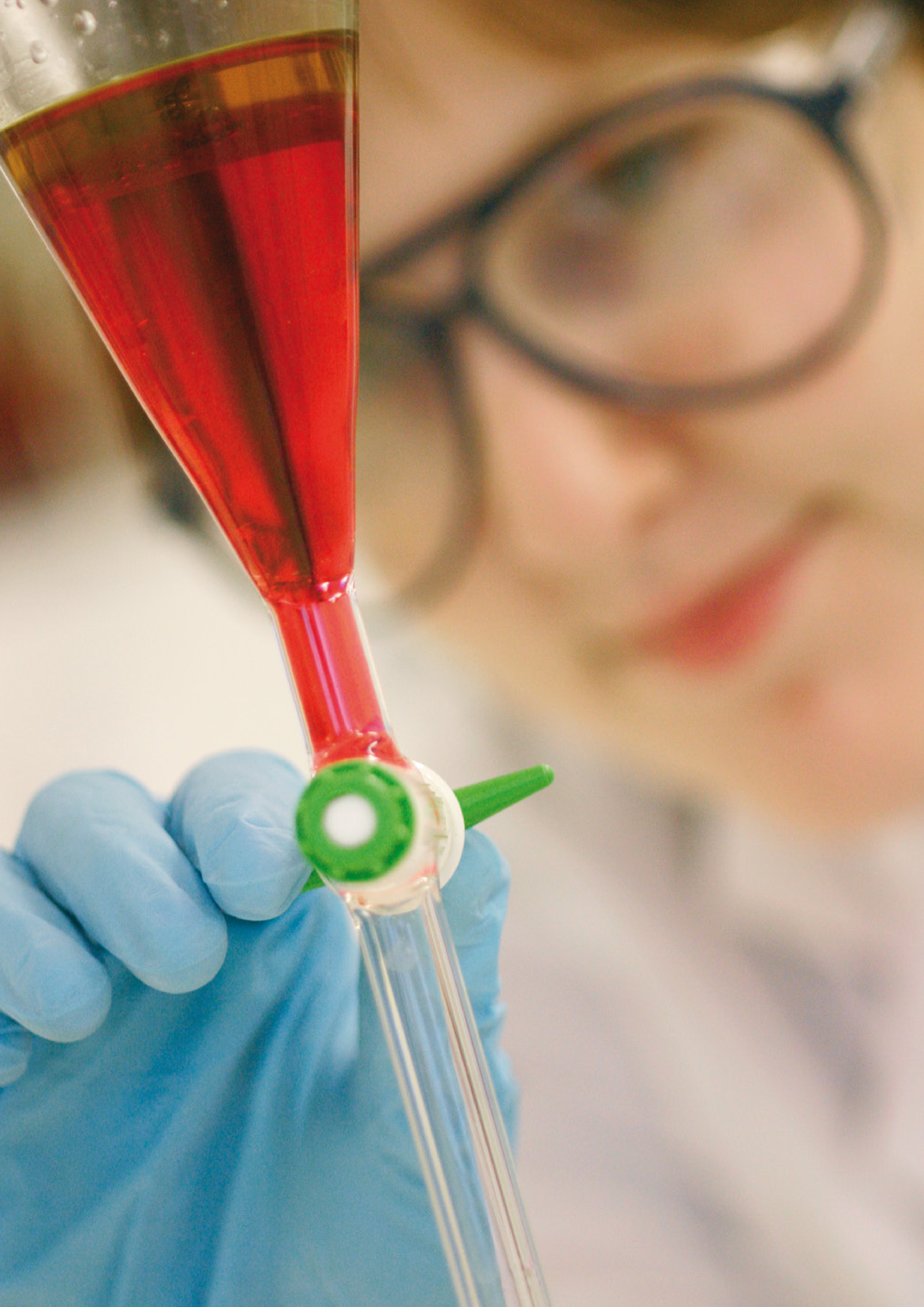
143. At Coventry University a scheme was introduced to the civil engineering programme where part-time students with industrial experience acted as mentors for full-time first year students. The motivation for the scheme was to combine the benefits of industrial mentoring and peer mentoring by creating structured contact between full-time first year students and fellow (part-time) students with current professional experience. It aimed to help first year students understand where their studies are leading, to allay fears regarding their knowledge of the civil engineering profession, to ease the transition to engineering studies, and to give them contact with fellow students whose skills, attitudes and motivation have increased their chances of success on the course. It also aimed to provide professional skills development to part-time students.

144. Although the experience was appreciated by mentees, their level of engagement was inconsistent, and while mentors reported gaining personal satisfaction from their involvement they did not view it as a significant form of professional development. Overall the scheme was seen to offer a number of positive benefits, and while it continues to be offered, it is now more deeply embedded within faculty wide processes and systems. For example, it is now offered to full-time students in their first and second years, and students who are seeking a work placement particularly appreciate the opportunity to secure insight into the workplace and to establish a professional network. Further, it has been rolled out to other universities:

"The initiative for using part-time students as mentors, started at Coventry, is now being adopted (with support from the National HE STEM Programme) at Derby, Nottingham Trent and London South Bank University." [Project Report, Part-time students in the workforce, Coventry University]



Section 7:
Meeting Employer Needs

Introduction

1. The development of the National HE STEM Programme commenced in the autumn of 2008, a time shortly after the production of the then Government's strategy for equipping the UK workforce with the skills it required for an innovative and competitive economy. The report 'Higher Education at Work - High Skills: High Value[1]' made the role of the Programme clear: it needed to focus upon developing the knowledge and skills of both undergraduates and those currently within the workplace:

> **"We have set ambitious targets in response to the analysis of our skill needs to 2020 by Lord Leitch. Meeting them will require a culture shift among higher education providers and employers. Employers need to be ambitious and demanding in the strategies they set for their businesses. Universities need to help organisations through knowledge exchange as well as by supplying skilled graduates and post-graduates and by providing high level skills learning for those already in the workforce." Bill Rammell MP, Minister of State for Lifelong Learning, Further and Higher Education (2008)**

2. With widening participation underpinning all aspects of the Programme's work, the emphasis for working with those in the workplace was upon learners without a prior university level qualification. Encouraging such individuals to engage with university level learning is itself a widening participation objective for the STEM disciplines. Furthermore, Government reports at the time had indicated there existed a potential 'pool' of over 10 million learners without level 4 qualifications who might be encouraged to apply and engage in further study[2].

3. During the almost four year period between the Programme's inception and its conclusion in July 2012, it operated in a period of great change within the UK; economically, politically and educationally. While the prominence, and importance of the Programme's other strands of activity have remained, or even increased over its lifetime, the importance of its workforce focused activities were not always clear. Implicitly they remained important, but they were never promoted and championed in quite the same way at the highest levels once the Government changed in May 2010.

4. This, however, changed in February 2012 with the publication of the Wilson Review which recommended a **"new covenant between business and universities: a covenant that generates partnerships and collaboration, a covenant that can only be achieved through greater communication**

[1] http://www.bis.gov.uk/assets/BISCore/corporate/MigratedD/publications/H/Higher_Education_at_Work.pdf

[2] University is Not Just for Young People: Working Adults' Perceptions of and Orientation to Higher Education, DIUS (2008)

and understanding." The review also asserted the need for increased engagement with the range of businesses and employers, and in particular SMEs. The role of the Programme in working with employers had been reinforced, and its activities were meeting just these themes.

"The data gathered presented a rich picture of different engagements with a wide range of employers and from our survey we found that the themes aligned with the Wilson recommendations, in that they had a focus on partnership, communication, collaboration and enhanced understanding of developing employer alliances." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

5. The Programme's work to develop the skills and knowledge of undergraduate students, often in collaboration with employers and employer organisations, has been discussed extensively within Section 6. Participation was not quite so universal for activities to provide opportunities for those within the workforce and society to develop enhanced knowledge and skills:

"There is ample evidence that the extent to which this type of activity related to the strategic priorities of the university was important in determining whether it was seen as a peripheral activity or a central function of the HEI." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

6. For those universities that did participate, engaging in activities with the workforce were found to beneficial, both in terms of enhancing the activities with full-time undergraduates, to unexpected business training opportunities:

"Whilst the programme developed at Swansea Metropolitan University will remain a part-time provision…full-time students are already benefitting from relationships with the extended range of companies that are engaged in this project. For example, students have undertaken study visits to some of these companies, there are new opportunities for full-time students to undertake industry-based or related project work and material developed for delivery on the part-time programme can be used to inform relevant aspects of the full-time Mechanical Engineering programme." [Academic Member of Staff, The Steel Academy, Swansea Metropolitan University]

"In addition to the development of the academic programme, there were other unexpected spin-off activities. Two companies felt that they were not yet ready for a degree programme, but needed some specific higher level training. As a result two Level 4 training programmes were developed to meet these needs. These were highly successful and the programmes were extended to cover a much wider range of employees than had originally been intended." [Academic Member of Staff, The Steel Academy, Swansea Metropolitan University]

7. As this section will demonstrate, those universities that did participate in this strand of activity benefitted from the approaches through introducing new ways of working, of operating across institutional and organisational boundaries, and developing flexible provision that aligns with the needs of a new learner constituency. The Programme's Regional Action Plan projects, led by the Spoke universities,

were the dominant mechanism by which its workforce development activities were delivered. This reflected the desire of the Programme to build sustainable interactions at a regional level.

8. The Programme's commitment to build upon effective practice and prior learning was equally evident within its workforce development strand. A number of the successful Regional Action Plan Projects were undertaken by universities (the Universities of Bradford, Northumbria, Coventry, Teesside, York, the Open University, and the North West Universities Association via the North West Higher Level Skills Pathfinder) that had participated in the HEFCE funded Transforming Workforce Development Programme. While the same individuals did not necessarily lead the projects, and this complementarity perhaps reflects more the culture towards workforce focused activities in these institutions, it provided an opportunity to draw upon learning and good practice, and extend knowledge and expertise to new areas and programmes of study.

9. This section highlights the approaches Programme projects have taken in influencing institutions to develop or extend their relationships with employers through workforce focused activities. It focuses primarily upon 29 Regional Action Plan projects and three of the Spoke legacy projects. Given the importance of the Programme's Regional Action Plans projects to further its work in this area, the report by Kettle and Smith entitled 'Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects' is used as a basis for this section.

Drivers for Project Development

10. The development of Regional Action Plan projects commenced early in the second year of the Programme, and was undertaken by the Spokes working with their regional universities on the development of proposals. The opportunity to develop proposals was available to all higher education institutions although a national call was not offered. A regional approach was preferred as it allowed Spokes to utilise the intelligence and relationships they had gathered and generated since the Programme began to develop and deliver activities that were appropriate to the needs and priorities of their regions. It has already been noted that a number of higher education institutions, who were particularly active in the other aspects of the Programme, did not engage with the Programme's workforce development activities. It is perhaps helpful to explore the rationale and motivations for those that did.

11. The drivers for universities wishing to participate in the workforce development activities of the Programme varied. The Legacy Projects, which each Spoke university was asked to undertake, were predominantly motivated by institutional priorities for employer engagement, graduate employability and workforce development. For example, the Manchester Metropolitan University project was designed to implement a change in delivery by developing 'applied training' that is more flexible to employee and employer needs. It also sought to facilitate the development of more extensive relationships with

further education colleges in the local region. The University of Southampton Legacy Project explored new approaches to providing training for work based learners in electrical engineering within the power industry by working with National Grid and Mott MacDonald. The project arose as a result of a direct approach, but was based around existing relationships that had developed between the University and key personnel within the power industry as a result of the 'Power Academy'. Similarly the Hydrographic Academy resulted from a direct approach by Fugro to Plymouth University to discuss the potential of distance learning to meet the needs of the offshore industry.

12. In Wales the situation was slightly different as the Legacy Project was based outside of the Spoke at Swansea Metropolitan University in conjunction with Glyndŵr University [Case Study 62]. The project however, also arose as a result of a need by business and industry in Wales for skills development activities in engineering. Like the University of Southampton legacy project, this too was based upon prior relationships that Swansea Metropolitan University had developed with employers. While the companies themselves were looking to develop their workforces in order to maintain competitiveness in a global marketplace, Swansea Metropolitan was also interested in further developing its provision to improve access to higher education for adult learners in response to the Wales Government higher level skills agenda.

13. The Regional Action Plan projects also had a variety of drivers for their development including the opportunity to explore new markets for learning. The BizzUP and STEMBUG Gateways [Case Study 58] were developed, in part, as a response to a lack of understanding of the appropriate methods of effective engagement between higher education institutions and business and industry. The main focus of both projects were to raise awareness of the opportunities, services and facilities that were available to business and industry at higher education institutions in the Solent sub-region and the North West region, and develop a portal for employers to access resources for workforce training and development.

14. A key driver for BizzUP was to provide a brokerage service that would enable SMEs across the Solent sub-region to engage with universities for interns, recruitment, curriculum involvement and small-scale research or feasibility studies.

"Most of the feedback from SMEs and their supporting organisations described little contact (if any), previous unsuccessful engagements, or that they had absolutely no idea what services were on offer from HEIs. Most businesses found the existing university websites and services almost impossible to navigate, usually out of date and full of information that required far too much time to decipher as most of the language and terminology was unfamiliar." [Project Report, BizzUP, University of Southampton]

The Gateways contain this information to aid the engagement of higher education institutions with business and industry. For example, STEMBUG includes information on placements, internships, knowledge transfer partnerships (KTPs), higher apprenticeships, recruitment contacts and a large database of higher education expertise, such as research capacity and facilities, across the STEM areas.

15. At the Universities of Wolverhampton and Sunderland, the Gearing up for Industrial Growth and Flexible CPD for the Healthcare Science Workforce projects were designed to respond to developments occurring within regional and locally based industries and businesses. At the University of Wolverhampton for example, the project responded to local employer needs where the manufacturing engineering community have critical concerns regarding the demand

and supply of engineering graduates; the project worked to address these concerns through the development of a fast-track (2 year) manufacturing degree with a variety of progression pathways for learners.

16. The project at the University of Sunderland was a direct response to the Department of Health's new four level graded career programme known as Modernising Scientific Careers which is mapped against accredited university programmes of study. Providing learning opportunities to support this programme is particularly challenging for universities as the Department of Health specifies the curriculum exactly, including work-based learning, and has a strict accreditation process. The focus of the project was therefore upon developing provision that could meet the needs of healthcare employers for higher level skills, consider the requirements and prior backgrounds of learners, and align with the provision that the University itself could offer.

17. Several universities used their Regional Action Plan projects to review their existing provision and practice in partnership with employers, and with a view to either developing recommendations, or implementing employer focused provision in a tailored manner. At Coventry University, the Part Time Students in the Workforce project reviewed existing practice amongst a range of regional providers, in particular further education colleges and higher education institutions including the five collaborating regional university partners (the Universities of Coventry, Aston, Derby, Nottingham Trent and Wolverhampton), to test the attractiveness of current provision with employers. One outcome is that the collaborating universities are currently reviewing their provision with respect to group work. At Northumbria University, the project explored whether the accreditation of in-house company training was an effective mechanism for enabling the development of higher level skills and knowledge within the regional workforce to satisfy current and future needs. The project went on to develop new and specific work based learning modules which were then contextualised to meet the needs of three regional employers.

18. The Unclear about Nuclear project at the Open University had two primary drivers for its development. It was both a mechanism for exploring new strategies for utilising Open University short course resources and materials with a new market audience, and at the same time provided an opportunity to develop expertise in producing mobile applications (Apps) for direct use within modules of study. At Leeds Metropolitan University, the project aimed to engage employers in leading the development of a Foundation Degree in Building Engineering Services with Environmental Technologies, however this was closely linked to issues of financial viability and market considerations. It experienced opposition from employers who cited issues to do with uncertainty over higher education funding and time constraints, and so in response the final outcome was changed:

"In partnership with another institution who were to provide some of the technical support, meetings were held that moved the programme forward, in planning the technical content however what became clear was the need to produce the project outcomes in a different format and therefore in discussion with all of the steering group, a series of modules were produced that were beneficial to employers and students alike that could be rolled out in user friendly blended learning packages…The resultant outcome obviously was not as planned but was considered by the engaging employers and academics to be a sustainable option from that originally proposed." [Project Report, Employer Led STEM FD Development, Leeds Metropolitan University]

Engaging with Employers for Workforce Development

19. The Programme's higher level skills work had a specific remit to develop and improve relationships between higher education institutions and employers, and the different approaches adopted have given rise to differing outcomes. In some instances the activities have built upon existing relationships or groups which were able to provide direct access to employers; in others, initially exploratory relationships developed between higher education institutions and employers which explored whether longer-term mutually beneficial approaches could be implemented.

20. Where universities initiated proactive approaches to working with employers, these took a variety of forms including understanding labour market intelligence and needs, and understanding appropriate marketing and sales interventions to open dialogue. Working with other organisations such as Chambers of Commerce, Sector Skills Councils, and other employer facing organisations like the Institute of Directors, enabled relationships to be brokered and access gained to SMEs who are traditionally hard to engage by universities where a prior relationship does not exist.

21. Where an existing university-employer relationship was in place, this enabled activities to progress quickly as mutual trust and a shared understanding of joint working was already in existence. The University of Southampton had a strong working relationship with National Grid, primarily with respect to research and development through the Electronic and Electrical Engineering Group, but this had also extended to outreach activities as discussed within Section 4. National Grid also works closely with Mott MacDonald who provide project management services and consultancy expertise, and the Legacy Project demonstrated the benefits of engaging those companies who provide the 'supply chain' to larger companies. It meant that the project was able to expand understanding of where the demand for learning might be found, and identify increased instances of where skills developments might be needed.

22. For some projects, there has been a focus upon expanding knowledge of local employers and their needs to facilitate engagement with higher education institutions. The Universities of the Heads of the Valleys Institute (UHOVI) worked with local government Blaenau Gwent Regeneration Business Services to identify learning and training needs of employers across a range of sectors in the Welsh Heads of the Valleys. It faced a number of challenges including a potential lack of 'critical mass' in learner cohorts as regional employers rarely support large numbers of employees to engage in education and training, and competition from commercial providers offering targeted short duration training packages. These challenges were overcome by working with businesses on an individual and personal level, and offering to establish bespoke and tailored provision that met individual company needs:

"Academics in a STEM department in a University were keen to engage with a specific business sector. They engaged with certain larger companies over a period of months taking several meetings but failed to achieve a successful union. Sometime later as part of the UK STEM project we approached the same University STEM department with a proposition to encourage collaboration with the sector employers. The university were sceptical of success as one might imagine. However we were able to access the employers independently to better understand their specific needs. We then spoke again to the University academics, but again separately to establish a more tailored offer. Through this new intervention, negotiations have re-opened with indications of a positive result in the near future." [Project Lead, STEM Employer Engagement and Workforce Upskilling in the South Wales Valleys, Universities of the Heads of the Valleys Institute]

23. The importance of communication between employers and universities was continually reinforced by the Get STEM Working project led by the Bournemouth University, but this highlighted that inherent barriers exist in this regard within higher education institutions. Other projects reinforced this:

"From the outside, especially to employers with little or no previous experience of working with an HEI, the institutions can feel rather 'impenetrable'. It is often not clear what HEIs can offer – both in terms of activity and intended benefits – which HEI to approach, and who within the organisation they would need to contact to explore these opportunities." [Project Report, Progressing from Labour Market Intelligence to HE Level Provision, University of Exeter]

Given the communication issues that exist between Universities and employers, easy access Gateways or brokerage schemes provide a means of overcoming such barriers, however where relationships are being brokered a degree of impartiality is important.

24. UHOVI is a strategic partnership between the University of Glamorgan and the University of Wales Newport. Backed by Welsh Government it works closely with further education colleges and training providers, local authorities, businesses, schools and the voluntary sector in a collaborative effort to provide opportunities for local people and businesses. As such, it is independent of any one university, but is able to represent higher education interests and work in a brokerage or commissioning role that is not led by the need to provide a specific 'offer'. Similarly the development of North West STEM CPD provision, a suite of 26 modules (ranging from 5-20 credits) across five higher education providers, was led by the North West Universities Association following a gap analysis that was undertaken independently of the higher education institutions themselves:

"Initially NWUA worked with the STEM cluster of Sector Skills Councils and other sectoral organisations in the North West region to understand the needs of industry for level 4+ CPD in relation to the STEM workforce. This was then compared to the current CPD provision across the region and a gap analysis produced. The gap analysis then formed a priorities document for CPD development and NW HEIs were asked to bid to NWUA to develop new provision which met these priorities in partnership with employers." [Project Report, North West STEM CPD, North West Universities Association]

25. In the Solent sub-region, the BizzUP project developed 14 engagements between universities and businesses through employers using the website, and the more focused 'face to face' brokerage

established 24 engagements between SMEs and higher education institutions. However, BizzUP was led, and hosted by, the University of Southampton, and while it proved successful in terms of brokering interactions, its activities could not be sustained through the original delivery model:

"…the project was incompatible with the mission objectives of central service departments at the host institution, which elected not to sustain the activity beyond July 2012." [Project Report, BizzUP, University of Southampton]

26. The Manchester Metropolitan University Legacy Project utilised learning from the North West Higher Level Skills Partnerships, and utilised further education colleges to gain access to employers having first 'audited' the colleges to explore where complimentary strengths existed. In a similar manner, the University of Greenwich built on an existing network, the Business Innovation Group Kent, a regional network for the Manufacturing, Engineering and Technology sectors, and in undertaking the activities of the project this was naturally extended:

"…a specialist strand within the BIG-Kent network was created to promote the HE STEM program under the banner of BIG-STEM. As a result the University has now deepened links with Chambers of Commerce, Institute of Directors, Education Business Partnership, News & Media organisations, Employer Federation and Professional bodies. Through these links the general awareness has improved significantly about the University's flexi mode program, STEM facilities and capabilities and business support programs. In particular the initiative has been successful in influencing the employers and employees' perception of short courses as a stepping stone for flexi mode higher education and the notional need to implement staff development budgets for such specialist courses among employers is a remarkable achievement for the project." [Project Report, Business Innovation in STEM Sectors by Workforce Upskilling, University of Greenwich]

27. The use of the BIG-STEM network meant that the University was able to identify clusters of companies in the electronics and communications and waste-to-energy sectors. As a result two new short courses in electronics manufacturing and reliability engineering were developed from scratch, and a third course adapted to focus upon biomass handling and storage. Several 'reach out' sessions were carried out with companies, and as a consequence four short course sessions were run attracting 45 participants from 27 companies and generating income totalling approximately £18,000.

"The short courses developed during the project will be offered regularly in future assessing market trends on a continuous basis…UoG is looking into opportunities that can complement the BIG-STEM effort, for example, developing a new short course entitled "Green Energy" which is expected to be added to the suite of courses already offered. The project team is also developing an action plan to contact companies on individual basis to assess if there is a market for other customised short courses in their respective sector and flexible delivery modes to improve uptake." [Project Report, Business Innovation in STEM Sectors by Workforce Upskilling, University of Greenwich]

28. Where existing grouping of expertise were not in existence, projects found it helpful to assemble such groups. At Gateshead College a working group from the motor industry and the emergency services were assembled to explore the implications of green technologies, and from this identified

the training needs of a range of stakeholders including the emergency services and recovery personnel. As a consequence, Gateshead College developed and delivered 6 new programmes for high voltage vehicles including a bespoke BTEC programme for the emergency services:

"Due to the success of the training provided and from feedback received from employers and learners. The college has decided to adapt these courses and create an e-learning environment which will enable learners to prior to attending the course complete the pre-assessments. By doing this it means that employers will not now attend the full duration of the course." [Project Report, The Science of Low Carbon Vehicle Technology, Gateshead College]

29. Similarly the University of Sunderland reported that a steering group consisting of key employer stakeholders was essential for the success of its project:

"This project could not be achievable without the engagement of the training managers and analytical laboratory departmental heads from the regional foundation trust hospitals. The project idea was presented to them at a training meeting at a local hospital and again at the regional Strategic Health Authority (SHA) and this led to the formation of an employer steering group for the project." [Project Report, Flexible CPD for the Healthcare Workforce, University of Sunderland]

30. A consistent message that has emerged from a number of the Programme's projects working with employers is that developing individual or one-to-one relationships is crucial to their success. The

Manchester Metropolitan Legacy Project found that using an experienced consultant to develop one-to-one relationships with providers was vital. Similarly at Swansea Metropolitan University the project manager accessed companies directly to broker and develop relationships. At the University of Wolverhampton, the Gearing up for Industrial Growth project adopted a different approach by consulting with a range of senior industrial managers through formal networking events in the first instance to develop relationships that could then be built upon.

31. At Anglia Ruskin University, the University's academic and technical staff spent time working at Huntsman's production facility to enhance understanding of their business needs in the global chemical industry. This engagement ensured successful relationships were fostered and helped identify that the development of two 15-credit modules delivered by blended learning would be the optimal approach for the Huntsman workforce. Fourteen employees from Huntsman are currently accessing this developed provision.

Collaborative Approaches to Workforce Development

32. In the current higher education climate, it might have perhaps been expected that many of the Programme's activities would be undertaken by higher education institutions in isolation. Section 4 has demonstrated however, that collaboration was a key and embedded feature of the Programme's work, and that there exists a strong culture of collaboration and shared working within the UK's higher education sector. The workforce development focused Regional Action Plan projects demonstrate not only collaboration between higher education institutions, but also the benefits to universities of doing so.

"The trust and foundations developed through the…project have proved that even competing local academic providers can work together to ensure regional development" [Academic Member of Staff, Succeeding in Tomorrow's Engineering World of Work, University of Huddersfield]

"Overall the HE STEM projects have reported that the activities have increased awareness of the needs of local employers and the skills gaps that can draw employers to consider local HE provision for learning and development. The projects have provided a space for real dialogue with employers in some cases and the involvement of employers with the undergraduate curriculum as well as explored opportunities for new provision." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

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33. Swansea Metropolitan worked with both Glyndŵr University and Swansea University to provide workforce development opportunities in skills shortage areas across Wales. A fast track level four pathway in mathematics and engineering was developed with Glyndŵr University, previously discussed in Section 6, to enable progression to higher level qualifications by those currently in the workforce with prior experience but with insufficient prior qualifications. This complementary approach allowed each University to tailor the provision to meet local employer and employee needs and enabled learning to be shared:

"The North-South partnership was a useful experience, in that it gave different perspectives on local conditions and on characteristic approaches of different institutions. Nevertheless, it demonstrated the validity of the original concept. A further partnership developed with the University of Wolverhampton, through the Practice Transfer Adopter programme. This has proved to be an excellent relationship, which will continue, and will explore further ways of collaboration beyond the original project." [Project Report, Fast Track Level 4 Progression Pathway, Swansea Metropolitan University]

34. While the programme will be sustainable at Swansea Metropolitan University as it has become embedded into its existing provision, it is unlikely to be sustainable at Glyndŵr University even though it was acknowledged as offering benefits to both learners and academic staff:

"The project at Glyndŵr has achieved its aim but may not be sustainable in present format, but nonetheless has provided valuable resource and a greater understanding of how the use of technology can enable a better student experience. The fast track concept however involving AP(E)L is a good one. Institutions wanting to attract more work based learners know that for both employers and work based learners, time and cost are always an issue. So being able to recognise existing credit and experience, benefits all parties. However if AP(E)L simply serves to reduce revenue to institutions while adding complexity and cost, there may not be strong motivation to develop systems to handle it." [Project Report, Fast Track Level 4 Progression Pathway, Glyndŵr University]

35. The collaborative activities undertaken between Swansea Metropolitan University and Swansea University as part of the Steel Academy Project, discussed previously in Section 6, has seen the development of an integrated approach to providing learning opportunities for those working in the steel industry in Wales. It has also led to a much closer relationships between the Universities, and with employers such as Tata Steel:

"An important aspect of the project is the impact it has had on participating universities, both in terms of improving relationships with each other and with key employers in the metals sector, with whom an excellent working relationship has been established." [Project Report, Steel Academy, Swansea Metropolitan University]

36. In the South West, two Regional Action Plan projects were undertaken as large projects involving collaboration amongst higher education institutions. The GET STEM Working project led by Bournemouth University involved six sub-projects, each led by a higher education institution from across the region. The collective aim of the project was to improve employer engagement with the STEM undergraduate curriculum to provide contextual relevance, employability skills, and cross

disciplinary applications of working. The model was flexible and meant that each institution could address an individual need or priority, but that working within a common framework would allow learning to be shared.

37. For example, Bournemouth University itself built upon existing relationships (with companies including Nokia PLC, Anglepoise Limited and Gelert Ltd) and practices to develop a methodology for promoting the benefits of companies providing experiential learning opportunities. One output has been a self audit toolkit, and the project operated during a period when employer engagement took on an increasing profile within the University which provided an opportunity to influence wider practices:

"Design, Engineering and Computing has been successful in achieving funding from the Royal Academy for Engineering for a Visiting Professor in employer engagement (Innovation). The School's involvement in a number of HE STEM employer engagement projects including RAE STEM funding to validate a new MEng Engineering has contributed to this successful award… The STEM projects have raised awareness within the School and the wider institution and recommendations are being taken on board strategically within the institution and the School." [Project Report, Employer Perspectives of Employer Opportunities to Engage with the Undergraduate Curriculum]

At the University of the West of England, online meeting technology and videoconferencing technology enabled effective engagement between students and employers as part of Year 2 undergraduate courses:

"The Department of Applied Sciences at UWE has indicated that it is supportive of this extremely beneficial activity and intends to allocate a modest resource each year to enabling it to continue and develop...These changes and developments will ensure that the activity can be sustained, especially as relationships with employers are developed." [Project Report, Technology-enabled Employer Engagement in Analytical Chemistry, University of the West of England]

38. Similarly the Progressing from Labour Market Intelligence to HE Level Provision project, which also involved six higher education or further education partners and coordinated by the University of Exeter, developed a range of initiatives at each institution to engage engineering employers in higher level workforce provision more effectively and sustainably. It achieved this by providing detailed intelligence about employer demand, reviewing the nature and impact of existing processes of employer engagement and developing new approaches to employer engagement and embedding these within higher education institutions in the South West. The process of partnership working enabled them to identify common issues and to learn from across the individual projects.

"…the sub-partners involved in this project were all at different stages in their thinking about employer engagement and faced different issues. The process of partnership working enabled us to identify common issues and to learn across the sub projects" [Project Lead, Progressing from Labour Market Intelligence to HE Level Provision, University of Exeter]

"The emphasis in the immediate future will be on developing the relationships with key companies rather than approaching others. In this way it is hoped that we can develop some bespoke training solutions which meet the employers' needs." [Project Report, A Partnership for Engineering CPD, University of Bath]

"…the project has resulted in a new system and awareness that will hopefully enable the development of new HE provision that supports the growth of local small engineering companies. Whilst the delivery and intended outcomes were useful the key challenges that were raised by the firms will require some further work to create solutions…" [Member of Staff, Developing a new CRM system for managing relationships with SMEs, Weymouth College]

39. For the North West STEM CPD provision, the involvement of the North West Universities Association in leading the project meant that it was successfully able to broker partnerships between universities who hadn't worked together previously; for example Liverpool Hope University, the University of Salford and the University of Central Lancashire are working in partnership to provide a suite of mathematical provision for STEM industries. As a consequence of this project, new short course provision addressing the needs of the aerospace, automotive, engineering, energy, textiles and construction sectors has been developed and embedded in five regional universities [Case Study 59].

40. The Manchester Metropolitan University Legacy Project collaborated with other education providers to improve access and transition support for learners. For example, collaborations were developed with further education colleges to improve connections with SMEs in the process industry sector where labour market intelligence has indicated there are significant level 3 and 4 shortages. These new partnerships have resulted in several outputs including a new franchised Foundation Degree Applied Science programme with Macclesfield and South Cheshire colleges, and maths applications (Apps) for android and iPhones developed as tools to address the specific mathematical skills and knowledge required for entry to level 3 and level 4 courses in collaboration with Stockport Further Education College; this model allows learning to take place off campus and in a creative and innovative way. The collaborations have also established dialogue around the support needs for higher level apprenticeships and the transition to higher education for apprentices:

"MMU, in conjunction with Cogent SSC and its associated apprenticeship training agency - TAS, have been successful in managing to both get the FdSc Chemical Science programme embedded into a Higher Apprenticeship framework and recruiting new apprentices onto this new higher-level pathway…Working closely with Sector Skills Councils (Cogent and to some extent Proskills) to identify core markets, has enabled links to be forged with major STEM-related organisations, e.g. BASF, EDF Energy and GSK. This work has now attracted wider Faculty attention, and a mapping exercise has identified several areas of common interest across wider Faculty (Science & Engineering) provision relevant to the new Higher Apprenticeships which are being developed under the current Higher Apprenticeship Fund." [Project Report, Developing STEM Up-skilling Services for the Process Industries in the NW, Manchester Metropolitan University]

Models of Flexible and Responsive Higher Education Provision

41. Through the Programme's workforce development activities, and indeed its higher level skills strand as a whole, new full-time and part-time provision has been developed within the STEM disciplines that was discussed previously as part of Section 6. A number of activities undertaken by higher education institutions as part of the Programme's workforce development activities have focused upon building capability within institutions to engage in workforce development, or building mechanisms, such as the STEMBUG and BizzUP Gateways to enable interactions between universities and employers to develop. While these activities have already yielded some outcomes, particularly in terms of influencing institutional approaches, it is in the longer-term that their impact will be most evident.

42. In addition a number of projects have focused upon making components of STEM study available to those within the workplace through a variety of models that typically involve smaller credit bearing units, accreditation of existing provision, or through short courses. The remainder of this section explores some of these more bespoke options that have been developed and delivered by higher education institutions.

43. Through its Keeping the Lights On legacy project the University of Southampton created a series of work packages targeted at core power engineering skills and knowledge, guided by power industry needs. The materials can be used for in-house training within the industry and now form part of the degree course for power engineering students. The model has not only allowed businesses to gain from upskilling staff and employees to benefit from sampling higher education, but the material has been used by undergraduate, postgraduate and workforce engineers on a Masters level course, and with Power Academy students to improve their knowledge prior to summer placements.

"Learners have been positive about the flexibility of access and the ability to revisit elements of the learning material independently. They can see the direct benefit to them in helping speed up their understanding in the topics covered. Compared with reading and working on pre-set problems they have found it much quicker and more engaging. The project provides an example of learning for people already in work that draws on their experiential learning in the workplace and builds new technical and practical skills and ensures learners are fully engaged and benefit from their learning experience."

[Academic Member of Staff, Keeping the Lights On, University of Southampton]

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44. The work packages are non accredited, and making them accessible online for off-campus and anytime access was important in securing the support of employers; equally it was essential they built upon learners' experience in the workplace by developing new technical and practical skills. To deliver provision online, three different approaches were utilised: video tutorials, virtual

experiments and dynamic questions. The virtual experiments[3] have also proved popular with other higher education institutions, and through the Practice Transfer Adoption Scheme, six universities (the Universities of Kingston, Sheffield, Coventry, Staffordshire, Derby and Bradford) have received support and training to enable them to develop their own.

45. The Legacy Project at the University of Southampton has also had a more profound impact upon the institutional practices. The ideas and approaches have been incorporated into other teaching modules to allow sessions to become more interactive, and the approach to virtual experiments is being incorporated into the programme for the University's Malaysia Campus. The University of Southampton also worked with the Open University in developing virtual experiments, and as a further legacy, the Open University and the Wolfson Foundation are establishing an OpenScience Laboratory that will incorporate a number of virtual experiments[4].

46. The Legacy Project at Manchester Metropolitan University has enabled more flexible provision focused around both employers and employees to be implemented using both accredited and non-accredited models. A franchised Foundation Degree in Applied Science has been launched with Macclesfield and South Cheshire further education colleges, and as of September 2012, nine learners were participating in the programme. Additionally, the Faculty of Science and Engineering has been able to develop a framework for delivering bespoke professional development training to the Chemical Industry which has yielded successful outcomes and which is seen as a model of good practice across the University:

"…the commercial work undertaken has involved 1-day training provision on the worksite of the employer – with one employer already using the services available on three separate occasions (with more in the pipeline). Enquiries are now being made regarding the services available to develop unique 'laboratory' training resources to be used by an employer for in-house trainers to do their own internal training." [Project Report, Developing STEM Up-skilling Services for the Process Industries in the NW, Manchester Metropolitan University]

"Participation in the National HE STEM Programme has provided MMU with significant market intelligence on employer skills requirements and thereby helped us tailor new CPD and foundation degree provision to address these needs. Such market responsiveness has already increased demand for our courses in key areas and has enabled us gain accreditation under the Higher Apprenticeship Framework for Life Sciences & Chemical Science Professionals (England)" [Dean of Science and Engineering and Pro-Vice-Chancellor, Manchester Metropolitan University]

47. The Mathematics Support in the National Health Service led by the University of Bradford also provided non-accredited professional development support, this time to those within the National Health Service in relation to mathematics and numeracy. The project was motivated by a concern amongst those within the NHS regarding the mathematical and numeracy skills of some of its workers, and in collaboration with five NHS Foundation Trusts a series of contextualised resources and materials were developed for those delivering patient care.

48. In seeking to develop workforce focused provision, Leeds Metropolitan University, Sunderland University, Gateshead College and UHOVI all sought, at least in the first instance, to develop

[3] See for example: http://ve.soton.ac.uk/ves/electronics.html

[4] http://www8.open.ac.uk/choose/ou/openscience

Foundation Degree provision in conjunction with local employers but subsequently met with a number of challenges and had to revise their approach. For UHOVI this involved seeking to develop longer-term relationships through a more brokerage type role, which included the development of 'sticky clusters', clusters of employers with common interests in order to develop a potentially 'critical mass' of future learners:

"After detailed early discussions, cluster representatives indicated a willingness to engage with UHOVI and Blaenau Gwent Regeneration services to identify common accredited training needs. A detailed 'Information Request'…[has] generated a list of training 'targets' with common themes. This has enabled UHOVI to identify a critical mass of learners across the companies and encourage external engagement." [Project Lead, STEM Employer Engagement and Workforce Upskilling in the South Wales Valleys, Universities of the Heads of the Valleys Institute]

For the other universities, this involved significant changes to their planned delivery models.

49. The steering group of the Flexible CPD for the Healthcare Workforce project at the University of Sunderland initially identified topics for the training of healthcare assistants and associates which resulted in the development four modules. The modules were developed as flexible learning opportunities, and formally approved by the university as a 40 credit short course. Once the short course had been developed it was sent out to a larger group of 25 regional National Health Service employers to garner their opinions; the feedback was unexpected and conflicting:

"Some felt that the short course was not what they wanted but that they really required a full FdSc Healthcare Science for their assistant/associate staff as part of MSC [Modernising Scientific Careers]. Others felt the short course alone would be sufficient to fulfil the training needs of those staff on basic pay bands. Some employers felt that the potential students who would undertake the course would not be able to study independently and at a distance and needed more face-to-face support. Others acknowledged the benefits of employees studying in their own time and not being away from the workplace for long periods of time." [Project Report, Flexible CPD for the Healthcare Workforce, University of Sunderland]

50. In response, the University identified two alternative training routes, the first involved the Short Course model but delivered through its virtual learning environment, and the second was to develop a Foundation Degree in Healthcare Science which would take place after the conclusion of the Programme. Six

hospital employees participated in the pilot evaluation of the Short Course, and 16 when it formally commenced in May 2012. The Foundation Degree model is now currently being progressed:

"As a consequence of working collaboratively with employers and the innovative employee evaluation of the material, the university is putting together a FdSc in healthcare science and the credit obtained by successfully passing the short course can be used to contribute to the FdS. The project has influenced the teaching and learning developments in the department by acting as a pilot for the development of a FdSc which for the first time will be delivered in-house as opposed to being franchised at a local FE college. Unexpectedly it has also led to the co-curriculum development of a FdSc in Biopharmaceutical Sciences as many of the core modules on both programmes are similar." [Project Report, Flexible CPD for the Healthcare Workforce, University of Sunderland]

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51. At Gateshead College the original intent was to develop and deliver a Foundation Degree in Low Carbon Vehicle Technology for employees working in the motor industry in partnership with Nissan and Smith Electric Vehicles. The rationale for such a development was strong as a skills gap had been identified for engineers working in the production of low carbon and electric cars and only courses at level 2 and level 7 were available within the region. The project commenced by two members of staff spending one day per week each working at Smith Electric Vehicles; these placements themselves have resulted in unexpected outcomes:

"One of the results that came from [Name Removed] placement with is that Smiths Electric Vehicles have agreed that students from the college will be given access to work placement during the 2012-2013 academic year with Smiths giving a work based assignment to the students and a member of Smiths Electric will act as a mentor to the group." [Project Report, The Science of Low Carbon Vehicle Technology, Gateshead College]

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52. Gateshead College worked with the University of Sunderland, the accrediting body, to develop the Foundation Degree so that it aligned with the Masters degree in Low Carbon Vehicle Technology that the University was also developing. Module development was shared, but due to changes in the validation approach linked to higher education funding, the proposal to develop a Foundation Degree was cancelled, and instead a HNC/D might be instead developed in the future.

53. In parallel, the College developed six short courses which were taken by 12 learners from local employers. A rolling CPD programme has also been agreed with Nissan which will engage with staff from its battery manufacturing plant when it is completed in late 2012. Gateshead has committed to continuing developments and they will be supported by a new post in business development for IT and engineering.

54. In response to requirements in the chemical industries, the University of Reading has piloted a 20 credit flexible distance learning course for employees in the pharmaceutical, forensics, agrochemical and analytical services industries with CEMAS, an analytical services company. The course is delivered online over six months through distance learning, and consists of 18 sub chapters, each dealing with a specific aspect of analytical chemistry, relevant to the modern chemical industry; assessment is by portfolio. Also at the University of Reading the Enhancing HEI Engagement with the Satellite Industry for Workforce Upskilling project reviewed the current skills levels of graduates and apprentices entering the satellite and space industry sector, and analysed

the destinations of graduates from key courses. The skills levels have been compared with the skills requirements employers report, and the deficits have been communicated to universities and professional development course providers.

"The team at Reading University are already using information derived from the study to inform short course planning for Reading's involvement with the International Space Innovation Centre at Harwell." [Project Report, Enhancing HEI Engagement with the Satellite Industry for Workforce Upskilling and Informing Policy Makers, University of Reading]

55. By working with the Programme, Teesside University has been able to expand its Open Learning in Engineering programme by introducing a new level 4 transferable 30 credit flexible learning option on Reduced Carbon Waste Management. The development of the module was initiated with SITA UK, a recycling and resource management company, who noted that it would be studied by learners with a range of prior educational backgrounds. As a consequence the learning option also contains an Introduction to Technical Skills module to ensure it is accessible to all learners. A full trial with SITA UK was scheduled for October 2012 with around 12-15 employees:

"…the relationship with the primary industrial partner (SITA) has continued to grow such that they are now in discussion with the School of Science and engineering (SSE) to develop and accredit modules that can be compiled into a full programme to initially HNC level and eventually HND in Waste to Energy plant Maintenance and Operation." [Project Report, Foundation Studies for Reduced Carbon Waste Management, Teesside University]

56. At the University of Bolton the Industrial Dissertation for Professional Engineers project was provided at postgraduate level and enabled non-graduate and graduate engineers operating at a professional level to undertake an industrially-based dissertation to enhance their opportunities to become Chartered Engineers; it was focused upon students who were viewed as possessing graduate-level skills but who may not have had a formal degree qualification. The first cohort consisted of a small number of students, approximately 15 who undertook a number of modules in engineering, technology and computer skills, produced a personal development plan and received career counselling and guidance where appropriate. Those who successfully completed the programme were either awarded an Advanced Diploma in Professional Development or, for those with sufficient funds, continued on to a Masters degree programme. The work undertaken on this programme was incorporated by the University of Bolton in its new engineering programme which was validated in March 2012.

57. At Cardiff Metropolitan the ENGAGE Design Management Programme recruited three groups of STEM based SMEs and used an approach that included workshops, one-to-one support, and the development of a bespoke diagnostic and implementation plan to help build confidence and capability in how they develop new products or services.

58. The core of the programme was the delivery of five key workshops over three to five weeks, during which participants worked together to explore the issues raised. On returning to their businesses the participants were required to apply the insight they had gained to their specific circumstances and ultimately use this as framework to develop a bespoke action plan for the management of design within their own organisation. The programme proved a success; not only did 20 individuals

participate in the full programme, but all were able to identify changes in their approach to innovation management in the future.

"The HE STEM programme has enabled PDR [National Centre for Product Design & Development Research] to develop material for a Design Management programme that will be applied and further developed at least until September 2015…In addition, the development of the HE STEM Design Management Programme has provided a format for future cross-department programmes within PDR and the wider University that will be applied to deliver programmes including those for Service Innovation in both the private and public sectors."
[Project Report, The Design management Programme, Cardiff Metropolitan University]

59. In seeking to accredit the in-house training of three employers in the North East (British Engines, Siemens, and the Regional Science Learning Centre) one of the challenges that Northumbria University faced was that the initial discussions with the employers identified a form of recognition for workplace learning was needed which was not easily accommodated within existing institutional frameworks. As a consequence, existing frameworks needed to be adapted and expanded to enable the more flexible nature of accrediting in-house training to be accommodated.

60. Once the existing frameworks had been adapted, nine new and specific work based learning modules of between 10 and 30 credits were developed and contextualised to meet employer demands. A pilot was undertaken in the University during which learners equivalent to 7.5FTEs (full time equivalents) engaged with these newly developed credit bearing modules; learners ranged from apprentices, those in team leader type roles, and technical staff, some of whom had no prior higher education experience up to those who had prior qualifications at level 8. A framework has now been developed to enable the accreditation of in-house learning at levels 4 – 6 leading to a recognised University award:

“The significant outcome of the project is the development of a proposal for a framework which is flexible, whilst remaining transferable across a range of STEM organisations. It will provide for the future a simple process to follow for employers to accredit their own in-house training in collaboration with Northumbria University.” [Project Report, Is Accreditation of In-house Training a Flexible and Responsive Model for Up-skilling STEM Staff?, Northumbria University]

61. The University of Plymouth adopted a somewhat different approach with the development of its statistical literacy course by making the materials freely available. The University originally intended to deliver the course through online learning, but found that contact sessions were a vital part of the learning experience, and so instead it developed a tutor’s handbook and supporting materials in order that they could be utilised by others to train students. While the course was delivered seven times by representatives from the University of Plymouth to 84 professionals with a range of responsibilities in Road Casualty Reduction, from Road Safety Officers to Data Analysts and their supervisors, delivery of the course will continue, but independently of the University:

“The courses continue to be developed and delivered by Devon County Council, through a regionally focused training academy. Their brief is expanding. We anticipate that Cornwall Council will also contribute to the delivery of these courses. As the Data Insights materials are maintained on a GitHub repository these will continue to be made available in their most enhanced form.” [Project Report, Enhancing Workplace Statistical Literacy, Plymouth University]

62. The networking opportunities Programme partners facilitated enabled the introduction to be made for a representative from the Enhancing Workplace Statistical Literacy project to contribute to the development of the statistical element of the distance learning curriculum of another project, despite both leads being based at the same University.

63. The Hydrographic Academy at Plymouth University [Case Study 56] developed and trialled a methodology for providing workforce upskilling opportunities to those in the offshore survey and engineering industry who are limited in their opportunities to engage with the higher education sector by the nature of their extended deployments offshore. The high salaries and staff costs associated with the offshore industry mean that release of personnel to study full time is seldom advantageous to the individual or the employer, and for some time, there had been an unfulfilled demand in the industry for an educational solution which enables the workforce to develop and enhance their qualifications, including the opportunity to gain professional body recognition. In particular Fugro, the world’s largest supplier of geoscience, survey and geotechnical related services, wanted to help individuals to gain accreditation by the International Hydrographic Organisation at both Category A and Category B levels of professional practice; many of the staff currently working in the offshore sector are experienced, but may lack formal qualifications, and there are relatively few with the Category A and Category B certification.

64. The Hydrographic Academy worked with Fugro, and the Royal Navy to develop an introductory 10 credit module which was trialled with a group of 12 students who were employees of Fugro. Learning materials were assembled into a package, stored on a memory stick, and mailed to the students. The materials integrate with further online content when learners have access to an internet connection, and this also provides access to tutor support and opportunities for peer discussion.

65. The success of the Hydrographic Academy has been significant. Over 420 potential students registered their interest in studying with the Hydrographic Academy since its formal launch in March 2012; around 100 of these are now formally registered to start a course over the next 12 months. It has also stimulated a number of further developments at Plymouth University:

"Plymouth University, through its School of Marine Science and Engineering has taken the decision to continue the investment in the HA for three years (until summer 2015) in the first instance; funding has been made available for the employment of a full time Project Manager, and for additional members of staff to enable a full distance learning programme at undergraduate and postgraduate levels, meeting the Cat A and Cat B requirements to be developed." [Project Report, Hydrographic Academy, Plymouth University]

Views of Learners and Employers

66. Given that the focus of the Programme's work discussed within this section is upon building relationships between higher education institutions and employers, and providing learning opportunities to those within the workplace, it is perhaps appropriate to conclude by 'hearing' a few of the views of those from outside of the higher education sector who have engaged as partners or as learners:

"Fugro's involvement [in the Hydrographic Academy] is driven by the need not just to raise standards but to make education more accessible and broader reaching given the on-going shortage of supply of suitably qualified and experienced staff. It provides an educational and qualification route for us that is not currently available other than through full time study." Global Learning and Development Manager, Fugro

"The CRASH course has given operators at Huntsman an opportunity to gain important knowledge supportive of their roles. The course has been designed to be highly relevant and meaningful to the participants, in ways that other qualifications do not achieve. The partnership with ARU helps foster Huntsman's commitment to ongoing training and development for our employees" [Site Manager, Huntsman Advanced Materials]

"The course has given us more confidence in interpreting data. Now when we hear or read statistical information on the TV or in the paper, we question it's accuracy and think of the what ifs." Employee, Devon County Council

"The technical information was my weak point and now I know the right questions to ask." Employer, ENGAGE Work Based Learning

"I have quite literally searched the world for an institution that offers this kind of tertiary education and from Australia to Europe I have been unsuccessful so thank you for your efforts! It's a huge step in the right direction!" Student, Hydrographic Academy

Section 8:
Sustainability of Programme Outcomes

Introduction

1. Within its March 2009 proposal to the Funding Councils, the National HE STEM Programme set itself a challenging series of objectives (Box 2.1). A key feature of these objectives, both explicit and embedded, was that the activities undertaken by the Programme should be sustainable within the higher education sector in the longer-term. Not only this, the Programme has sought to embed a longer-term way of working by encouraging sustainable collaborations and acting as a catalyst for change within higher education institutions.

2. This section seeks to explore the potential for the longer-term sustainability of the activities that the Programme has sought to embed within the higher education sector, and it builds upon the approach and methodology used for the Programme's Internal Sustainability Review which was compiled in September 2011 for submission to the Funding Councils. The evidence utilised within this section has been captured from a range of sources, but a key source is from the case studies and reports produced by each project lead describing their work within the Programme.

3. For the purposes of this discussion, it will be necessary to differentiate between 'sustainability' and 'legacy', particularly as the legacy of the Programme forms a section (Section 9) of this report. However, a natural overlap between the two is to be reasonably expected as their boundaries are often somewhat blurred. In addition, while the CFE External Evaluation considers sustainability at four levels (policy, sector, institutional, and activity/practice), the analysis that follows focuses primarily upon 'institutional' and 'activity/practice' levels. Consideration is however given to sustainability at a 'sector' level in terms of the extent to which developed networks and communities of practice might be sustained post Programme.

4. The previous sections of this report have explored the work of the Programme across its three strands, and as such have explored the impact and sustainability of these activities and practices within the higher education sector. In this section, the focus is upon an overarching look at sustainability within the context of the work of the entire Programme.

Sustainability vs Legacy

5. 'Sustainability' is a term that is used with a variety of meanings and for a variety of different purposes. For the purpose of this report, it is necessary to adopt a consistent definition, and within the context of the National HE STEM Programme, the sustainability of an activity is deemed to be

realised when: it will continue, in current or modified form, within at least the higher education institution(s) initially involved in its development and implementation, after National HE STEM Programme support ends.

6. Such a definition was utilised as the basis for the Internal Sustainability Review, however in that instance caution was needed as it required an activity to already be complete in order that it no longer required Programme support. When the Internal Sustainability Review was undertaken in September 2011, it was the case that the majority of Programme activities remained ongoing at the time, and so a variation upon this definition was applied which focused upon definite plans for sustainability by those undertaking or supporting the work. By this, it was meant that the individuals and HEIs involved made a clear and explicit statement of their plan to continue the activity post Programme and provided details of what that approach would be.

7. With the Programme concluding its formal activities on the 31 July 2012, it is now the case that all Programme supported activities have concluded, but this in itself does not make it any easier to make quantifiable and objective assessments on the sustainability of Programme Outcomes. This was noted within the Programme's External Evaluation:

"Robustly measuring sustainability is though inherently difficult when a Programme was only just drawing to a close. It is only when the external support has been fully removed for six to twelve months (or potentially even longer) that sustainability can be conclusively demonstrated." CFE, Summative Evaluation of the National HE STEM Programme (2013)

8. While an activity may appear to be continuing, it could equally be the case that its development is still continuing, albeit without the support of the Programme, or that insufficient evidence is currently available to make a judgement as to its overall effectiveness and as such whether it will remain a core future part of individual, departmental, faculty, or institutional provision. While the continuation of an activity immediately after the conclusion of a Programme is a significant positive, it is, at this stage, only an indicator of the longer-term sustainability that the Programme was seeking.

9. An activity needs to be continuing for a period of time in order to be judged sustainable, in either its original, or a modified form, and the three-year timeframe of the Programme makes this impossible to assess:

"...university programmes are reviewed in cycles (perhaps 3 years) with minor annual review of modules.....we are only now getting to grips with amending and supplementing resources, things like sustainability and continuation will depend in large part on how successful this initiative is seen to be in academic year 2011/12. We won't have exam results to compare with the current year until summer 2012. If they are really good we might have a chance of persuading some colleagues about adopting changes in 2012/13." [Academic Member of Staff, HE Curriculum Innovation and Enhancement Projects]

For an activity to be sustainable, it needs to offer some demonstrable, or perceived, benefit for those stakeholders involved. Such benefits might be identified in the longer-term through evaluation or research, but in the earlier stages could be indicated by the feelings or perceptions of staff, students and other stakeholders that the activity is offering some form of assessed benefit to the practices of a department, faculty or institution. Equally, activities might continue to be modified and adapted so that they exist longer-term in an almost unrecognisable form, or even exert a wider influence beyond what was originally intended that gives rise to more substantial change; here the activities will have a legacy, an influence that continues to live on, but which may be much harder to determine.

10. Given such challenges, another appropriate analysis is to explore longer-term potential for sustainability by considering a series of 'sustainability indicators' that were first introduced within the Internal Sustainability Review. The sustainability indicators give an indication of whether the environment in which the activity is taking place is conducive to it having a high likelihood of continuation beyond the end of the Programme? If so, these can then be used as a proxy measure to infer the overall likelihood of sustainability of the activity.

11. Sustainability and legacy are linked; if an activity is sustainable it naturally leaves behind, as a legacy, a new or enhanced practice that did not exist prior to the work of the Programme. Additionally, participating in the activities of the Programme might have led to wider influences with other aspects of the practices of an institution being enhanced or informed. The 'legacy' associated with the Programme's activities is therefore defined to be the influence that exposure to the work of the Programme has had amongst those who have participated in its activities. This definition not only includes any specific activities (projects) undertaken, but also where learning, resources, or collaborations have led to the development or enhancement of institutional provision, or a change upon the culture of an individual, department, faculty or institution:

"…there has been a massive change in institutional attitude to those lecturers who have no research responsibility. In summer 2011, I was part of a review team that drew up new promotion criteria to allow such lecturers to be promoted to Professor without a research profile. The term Teaching Fellow was abandoned and everyone is now referred to as Lecturers." [Academic Member of Staff, University of Exeter]

"We have mainly achieved the goals of our project, and have outstripped them in many ways. Employability has become the driving force of much of what we do with our students, and without this project this would not have happened." [Project Report, Identifying Skill Gaps of Employers and Mathematics Undergraduates, University of Leicester]

"The effect on faculty staff has been interesting, resulting in a good deal of reflection on their approach to teaching and the establishment of a new research interest in engineering education." [Academic Member of Staff, Swansea Metropolitan University]

12. While the legacy associated with those universities who have participated in the activities of the Programme will be explored within this section of the report, the legacy, with a particular emphasis upon continuation plans, of the six Spoke universities and four Professional Bodies who formed the Programme Team will be explored separately within Section 9.

Still a Case of Too Early to Tell?

13. The September 2011 Internal Sustainability Review asked the question whether, at the time, it was too early to make a reasonable, and meaningful judgement, as to the likelihood of an individual activity being sustainable. Of particular consideration was the fact that it was typically only smaller scale activities (less than £10,000) that by then had completed their work, and that the larger scale projects, operating primarily at departmental or faculty levels, remained very much active. It therefore seems pertinent to ask the same question again.

14. It is now the case that all supported activities of the Programme have completed, and as such Programme support has been removed. There also exists a much wider, and more independent evidence base upon which the Programme can draw. In addition to the individual case studies and project reports, there is evidence from the external evaluation of the Programme by CFE which independently surveyed 248 project leads in relation to their work, and semi-independent data collection and analysis of four strands of the Programme's activity to capture key learning. Furthermore, a number of projects have published the outcomes of their work in journals and other publications. All provide a much more robust evidence base upon which conclusions can be drawn, but with no guarantee:

> **"The analysis of this evidence gives an indication of the likelihood that the Programme's outcomes will be sustained, but by no means guarantees that they will be sustained."**
> **CFE, Summative Evaluation of the National HE STEM Programme (2013)**

This is consistent with conclusions reached by the Programme's former external evaluators, West Midlands Enterprise, in their external September 2011 sustainability review:

> **"…there are many reasons for expecting that widespread sustainability will be achieved at the project level, in terms of activities either continuing beyond the life of the programme itself, or giving rise to other activities that will carry the principles forward – though this certainly cannot be proved." West Midlands Enterprise, External Sustainability Review (2011)**

15. The CFE survey of project leads asked them to indicate the extent to which the work they had undertaken would be sustained beyond the end of the Programme:

"Our results indicate that the majority of respondents will be continuing STEM-related activities in some form, and in many cases the level of activity undertaken during the Programme will be continued or increased. Almost all (93.6%) involved with curriculum development and enhancement, 88.6% of those involved with HE engagement with schools and colleges, and 87% of those involved in graduate skills development intend to continue their project activities in some way. Two-thirds (65%) of respondents involved in workforce development activities indicated that they would continue their project activities beyond the end of the funding period to the same or an increased extent." CFE, Summative Evaluation of the National HE STEM Programme (2013)

Such findings are further reinforced by those obtained from semi-independent synthesis work undertaken across all three strands (Box 2.2) of Programme activity, and which explored a number of projects within each strand in detail.

"…the stakeholders questioned were generally optimistic about the sustainability of what had been achieved by their projects on the grounds that: the greatest expense had been incurred in meeting the initial development costs; changes have been embedded into programmes of study and can now be sustained out of departmental teaching and learning funds…" Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

"…projects have indicated they will continue with the developments beyond the funding period."

"The projects have developed change within HEIs at an individual course, department or faculty level."

Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

16. There remains, however, a need for caution before drawing longer-term conclusions as a number of larger scale projects have yet to fully evaluate outcomes and demonstrate their effectiveness, or have some unexpected challenges to overcome:

"The projects have in many cases provided pilots for new approaches to engaging employers, to changing curriculum or initiating new approaches in their discipline communities. They have generally not reached the stage of evaluating outcomes for students or measuring the effectiveness in enhancing the student learning experience." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

"The short course has now started and will continue until March 2013 so it is too early in the process to get any feedback from the employees or their employers." [Academic Member of Staff, University of Sunderland]

17. Additionally, one of the last open calls within the Programme was the 'Practice Transfer Adoption Scheme' which enabled higher education institutions to adopt and embed practices developed through the Programme. Implementation of the activities within the adopting departments commenced in early 2012, and as such, despite the activities being based upon effective practices, not all adopting departments are in a position to judge how effective these activities will be for them or their students:

"The Numbas server is deployed at Kingston…and its support and maintenance is guaranteed for 12 months. Beyond that timescale the School of Maths will resource its maintenance should the Numbas trial in academic year 2012/13 show the expected benefits to staff and students at Kingston." [Academic Member of Staff, PTA Adopter of NUMBAS, Kingston University]

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18. It therefore seems reasonable to conclude that the sustainability of the work established through the Programme looks positive, certainly at 'institutional' and 'activity/practice' levels, and particularly in the short and medium term. However, it still remains 'too early to tell' regarding longer-term sustainability prospects as these will only be evident some several years after the conclusion of the Programme.

Early Completing Projects

19. The Programme's Internal Sustainability Review included an associated annex which featured case studies of impact and sustainability of sixty Programme projects. Of these projects, 27 were marked as complete, and all projects indicated an approach to sustainability that would see their activities continue into the future. Using additional information project leads have subsequently provided to the Programme, their further engagement with the Programme to transfer and embed their practices more widely, or information gathered from a simple web based search, it has been possible to identify numerous examples of this work being continued, and in some instances, developed further.

20. Seven of the projects involved undertaking outreach activities initiated by the four pilot projects with a view to the universities involved incorporating them within their own practices. Many of these activities continue to be visibly offered as a part of departmental outreach provision. For example, the Mathematics at Work Day (University of Salford) ran again in June 2012[1], the Hampshire Mathematics Challenge (University of Southampton) was offered again in 2012 engaging 335 students[2], and the Pop Maths challenge (Manchester Metropolitan University) took place again in 2012 and is currently scheduled for March 2013[3]. At the University of Reading, activities derived from the Chemistry for our Future initiative form a core part of the departmental outreach offering[4].

[1] http://www.cse.salford.ac.uk/mathematics/taster-day.php

[2] http://www.southampton.ac.uk/maths/outreach/activities/hampshire_maths_challenge_2012.page

[3] http://www2.docm.mmu.ac.uk/STAFF/N.Rattenbury/PopMathsQuiz/

[4] http://www.reading.ac.uk/chemistry/outreach/chem-outreachindactivities.aspx

21. Eight of the completed projects resulted from one of the first open calls for projects that the Programme initiated (the Collaborative Projects Initiative). At the University of Nottingham, the pro-active interventions to facilitate transition for engineering students of non typical backgrounds not only continue, but they have been transferred to the University of Exeter. Similarly the Science Communication and the Media module developed by the University of Birmingham continues within both the School of Chemistry and the School of Biosciences, but has also been adopted by Queen Mary University of London and the University of Bradford.

22. Two projects focused upon computer based assessment, and eAssessment in mathematics and related disciplines continue to be a key feature at the Universities of Birmingham and Newcastle; further, their work was extended by an additional Programme project, and agreement has been reached through the Heads of Departments of Mathematical Sciences to maintain the community of practice that developed in this area. At Aberystwyth University, Gwydffan/Science Van continues to be a core part of physics based outreach, and the work at the University of the West of England to construct a coherent STEM strategy with schools saw a further five activity days take place with Bristol Schools in May/June 2012 engaging around 750 Year 8 pupils.

23. Other projects have contributed to an enhanced institutional approach. At Queen Mary and the University of Bath, the project leads of the STEM Communicator and Illusioneering projects, who were both also actively involved in the More Maths Grads Pilot project, actively contributed to their institutions securing support from Research Councils UK to establish Public Engagement with Research Catalysts[5]. Similarly at the University of Exeter, not only was the Outreach Community of Practice project extended, but it has resulted in an ongoing initiative now supported by the University of Bath[6]; additionally Exeter was also successful in securing a Public Engagement with Research Catalyst. While it cannot be claimed that the work undertaken by these institutions through the National HE STEM Programme resulted in the success of securing these Catalysts, it is known to be the case that the activities formed a component of their proposals:

"The senior managers at Bath were sufficiently convinced by the project to include it within the institutional bid for catalyst funding." [Project Report, Embedding Accredited STEM Communicator Models, University of Bath]

24. Further examples of continued activity are evident. A collaboration initiated between Queen Mary University London and the charity Generating Genius to support the progression into university of students from Afro-Caribbean backgrounds continues as evidenced by the commitment within their OFFA Access Agreement (see Table 8.1). At the University of Hull, the distance learning resources created for a foundation degree in the chemical sciences have now been extended to enable students to 'top-up' to BSc level via distance learning.

Indicators of Sustainability: Recently Completed Projects

25. Within the many final reports produced at the conclusion of Programme activities, there is both a clear commitment, intent and plan for sustainability; the series of case studies included within Section 12 of this report, developed from final project reports, demonstrates this. Further, in many of the reports or information that was provided by project leads to the Programme after its conclusion on the 31 July 2012, there is clear evidence of the activities continuing in the 2012/13 academic year.

26. While it is natural to treat such statements made by those running the projects with caution, such individuals are often best positioned to identify the potential for sustainability, and are ideally

[5] http://www.rcuk.ac.uk/per/Pages/catalysts.aspx

[6] http://www.hestem-thirdsector.org.uk

placed to put appropriate plans in place. In addition, they can indicate another important factor, the commitment and belief of those running the projects which will typically translate to a natural desire and work ethic to ensure they succeed.

27. For projects that have only recently completed it is not possible to accurately assess whether they will be sustainable in the longer-term at this stage, however it is possible to identify factors that will contribute towards the longer-term sustainability potential of an activity which may then be used as an indicator, and these may themselves already demonstrate short-medium term sustainability. This might be further resource, or a determined commitment:

"The sustainability of these activities will be supported by a new education engagement officer in the Faculty." [Project Report, Teacher Advisory Board, University of Leeds]

"We have to continue with this activity in some form. The project has enabled us to do more in a short timescale than we could otherwise have achieved…" [Project Report, A study of the key drivers in determining workforce engagement with HE level provision of training in the Aerospace Sector, University of the West of England]

Such an approach was first implemented within the Internal Sustainability Review, and revisiting it here is not only advantageous in terms of exploring potential for longer-term sustainability, but it also enables some of the principles (Box 2.3) the Programme sought to embed within its work to also be further explored.

28. For the Internal Sustainability Review an analysis of a range of project proposals, interim reports, case studies and other documentation from National HE STEM projects and activities was undertaken. This enabled a series of ten factors, or 'sustainability indicators' to be identified. These 'sustainability indicators' are factors that, when present, are likely to contribute to an activity being sustainable in the longer term and may therefore be used to make a reasonable judgement relating to the sustainability of an activity. In compiling this final report, an increased range of project materials were reviewed and as such formed a significant sample of the Programme's overall work across all activity strands, funding streams, and partners. This further analysis indicates that not only do these ten factors remain valid, but when completed projects analysed within the Internal Sustainability Review were revisited, they appear to function as reasonable indicators of the sustainability potential of projects beyond the end of a funding period.

29. Not all ten indicators need to be present within a given activity in order for it to have potential for longer-term sustainability, indeed it may be only one or two, and even then if all ten are present there is no absolute certainty. However what they do demonstrate is that there is some effect or influence that is making a valid contribution, or has a potential to make a contribution, towards sustainability. The ten factors are shown in Box 8.1.

1. **Embedding the Importance of Sustainability at the Outset:** Ensuring that sustainability is seriously considered by project leads during the development stage of an idea and is subject to rigorous scrutiny. Then, ensuring sustainability is considered and questioned throughout the lifetime of an activity. This will enable approaches to sustainability to be embedded from the start, rather than at the end of a project when it may be too late.
2. **Alignment of Activity with Wider Priorities:** The activity aligns with a wider set of priorities, and as such form part of a 'broader' picture. This might be institutional or national priorities, and as such provides opportunities for leveraging additional support or commitment.
3. **Institutional Commitment:** Buy-in or support is provided by the institution. This may be additional financial resource for development, to ensure on-going delivery, or in-kind support, such as the allocation of additional staff time or incorporation of the activity within workload timetabling.
4. **Evaluation:** Evaluation is an important part of the education development process. A robust commitment to (internally) evaluate should be in place prior to the commencement of any project. Evaluation is not only important because it provides evidence of impact, but also because successfully demonstrating impact leads to recognition, institutional or personal, which subsequently contributes to a sense of identity and the potential for wider opportunities and working.
5. **Dissemination:** Work to disseminate indicates there is a story to 'tell', and an individual belief in the ideas and learning being shared. It demonstrates a personal commitment to the activities and ideas.
6. **Professional Development:** Many developmental activities include a level of professional development. This means there is either individual learning, learning amongst others engagers, or a concerted effort to transfer the knowledge and expertise to others through mentoring or training events. Professional development is an indicator of sustainability, maybe not of the original idea itself, but of the ability to apply the gained learning or skills in a wider context, and within other institutions and with an almost unlimited potential for impact across the duration of an academic career.

7. **Developing a Community Identity:** Bringing together like-minded individuals or those who wish to learn from each other, share ideas and practices, or supporting/overseeing the ongoing nature of activities within a community through a co-ordinating and networking function.

8. **Wider value:** This might be termed 'transferability': the potential of an activity to extend beyond its initial institution to be used by others within the sector. It has clear value potential/benefit to others.

9. **Up-Front Investment:** Many developmental activities require an initial 'up front' outlay. This may be to develop resources, purchase equipment, or to buy-out staff time to develop necessary frameworks. After this initial work, ongoing delivery costs will often be lower if consumables are not involved. The significant resource cost then is staff-time which, if there is perceived to be benefit to an institution, can be allocated to the ongoing continuation of an activity.

10. **Proven Starting Point:** This is similar to 'Up Front Investment' but the development work and learning has already been applied elsewhere, and the opportunity exists to build upon 'what works' and commence the activity from an advanced starting point based upon the knowledge and expertise. Resources may exist, and the value and impact of the activity will often be evident.

Box 8.1: Sustainability Indicators within the National HE STEM Programme

Indicators of Sustainability Embedded within the Programme

30. The process of initiating change within higher education institutions is a longer-term investment, and its existence was unlikely to be fully demonstrated within the three-year timeframe of the Programme. Despite this, numerous examples of impact and legacy can be seen at a variety of levels, and there is significant evidence that the activities and practices established by the Programme will be sustainable. It is now appropriate to further explore the potential for sustainability of the large-scale activities that have only recently completed relative to the indicators in Box 8.1.

Embedding the Importance of Sustainability at the Outset

31. The importance of sustainable activity has been embedded within the Programme from the outset. This has been specifically commented upon by both West Midlands Enterprise and CFE within their external evaluation reports:

"…our judgement is that both in terms of design, and in terms of implementation, sustainability is being taken very seriously across the programme." West Midlands Enterprise, External Sustainability Review (2011)

"In implementing the Programme delivery model and commissioning projects/activities through the discipline strands, the regional spokes and the national hub, sustainability was a key selection criterion. There is evidence to suggest that projects/activities were rejected on the basis they offered limited potential for sustainability." CFE, Summative evaluation of the National HE STEM Programme (2013)

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32. All activity proposals were not only required to demonstrate a clear intent for sustainability, but also a plan for how this was to be realised. This approach meant that those activities which were never going to be sustainable, were not supported, and as such, this has undoubtedly led to a higher overall percentage of sustainable activities within the Programme. This is not to say that more innovative, untested, or perhaps even 'risky' ideas were rejected, but that even these needed to give careful thought as to what their longer-term future might look like if they were successful:

"It involved taking a risk and trying something new and untested. Over the last two years we have adapted our provision in regard to student feedback and have had to make changes due to University and other constraints. This project has succeeded in ways that had not been foreseen and appears to have made a real difference to student engagement retention and achievement which demonstrates the value of trying speculative ideas."
[Project Report, Maths Arcade, University of Greenwich]

"A risk was taken by combining two disciplines that are often seen as disparate, and that risk has proved to be worthwhile." [Project Report, Connect to Science, University of York]

"…the partnership delivering the National Hydrographical Academy provided 'proof of concept' to the University of Plymouth which is now resourcing it for the future."
Haselgrove, Engagement and Collaboration in the National HE STEM Programme (2013)

33. Progress towards sustainability was also monitored throughout. In particular within interim reporting, but also during networking meetings established in the final year of the Programme to bring activities together; this allowed approaches towards sustainability to be shared. A particular template used by the South West Spoke to encourage projects to reflect upon sustainability, and highlighted in the Internal Sustainability Review, was implemented by other Partners and evidence of its use can be seen within their final project reports and case studies of their projects.

34. The final template for project case studies or reports contained a specific section, 'Further development and Sustainability', upon which all projects were required to comment. This template was typically made available shortly after activities commenced, and as project leads were aware these case studies or reports would be made publicly available, it not only further reinforced the importance of sustainability, but highlighted that this would be a criterion by which their work might be 'judged'; this therefore encouraged sustainability to be taken very seriously.

Alignment of Activity with Wider Priorities

35. Activities are more likely to be sustainable if they are valued by others, particularly in terms of the contribution they might make to another agenda; this might be at a personal, departmental, institutional or national level. All can act as drivers, and indicators of sustainability, but for differing reasons. For example, individual priorities may relate to job roles or responsibilities, or more typically, to institutional or departmental priorities:

"The project team are however confident that in large part the changes will be made in a sustainable way, not least because of drivers from the University in response to employability figures and NSS scores." [Project Report, 2020 Vision: A Curriculum for Mathematics Graduates for the Next Decade, University of Birmingham]

"This project mirrors the ethos of the College, where all students are encouraged to become active participants in their learning." [College Dean, Adoption of SYMBΩL Project, University of Exeter]

"The increase in student employability represents a strategic programme for the School of Engineering and the success of this project means that this will continue as an exercise to enhance the student experience learning from its triumphs and challenges alongside our industrial partners." [Project Report, Integrating Industrial Expertise into the Delivery of an MEng Aerospace Engineering Module, Brunel University]

36. The aim and objectives of the Programme were deliberately focused upon supporting and encouraging higher education institutions to change and enhance their practices, and to do this, the delivery model needed to allow sufficient flexibility for individual needs and priorities to be met.

"A key piece of feedback from universities was that the order in which the stages were completed should not appear to be absolutely prescribed; procedures and requirements will vary between universities." [Project Report, Engineering Gateways PTP]

The Programme has enabled higher education institutions to take forward individually focused activities, but within a common framework and with an embedded series of values. This has contributed to diversity and variety across the sector, but has also enabled institutional missions and priorities to be fulfilled; as a consequence activities are likely to have an increased potential for sustainability.

37. An area where this alignment is most visibly evident is within the Office For Fair Access (OFFA) and Welsh Fee Plan Agreements, which has forced higher education institutions to think about not only how they recruit students and work to increase and widen participation, but also how they will support learners upon arrival at university. It is here where it is easiest to see how institutional activities, priorities and approaches map to the work of the Programme; there are many synergies, if not explicit relationships, between the content of institutional agreements, and the work they have participated in through the Programme. Table 8.1 explores this relationship further for the 2012/13 and 2013/14 statements.

HEI	Extracted Reference from OFFA or Fee Plan Agreement (2012/13)	Extracted Reference from OFFA or Fee Plan Agreement (2013/14)	Relation to the National HE STEM Programme
Aberystwyth University	*"We will support schemes to raise aspirations in STEM subjects from ages 7 to 14 (....... HE STEM maths challenge activities in 11 schools)."*	*"The mentoring scheme uses our undergraduate and postgraduate students in mentoring activities, working one-to-one or one-to-two on a weekly basis with students who have been identified by the schools as at risk of low attainment in Mathematics or Science subjects."*	Aberystwyth has participated in a range of outreach activities and interventions using student ambassadors.
Aston University		*"STEM Ambassadors will be recruited to encourage the study of maths, science and engineering in schools. The number will rise to 30 by 2013/14…From Spring Term 2013 more than 30 Aston students will act as volunteer mentors/tutors for learners at the Academy. We will roll out our innovative Engineering CDIO interactive learning programme."*	Aston has undertaken two large projects in engineering education focused around employability and employer engagement[7]. They also participated in the UTC Practice Transfer Partnership which developed a mechanism for engaging undergraduates with the work of UTCs.
Bangor University		*"We will work collaboratively across the region to extend opportunities for under-represented groups to engage with and gain experience of HE through extending STEM outreach activities and introducing taster activities aimed at specific groups to improve access to and understanding of HE."*	Involved in a range of outreach activities, including Spectroscopy in a Suitcase.
University of Bath	***"Reduced fees of £4,500 for placements undertaken during the course of the 2012/13 degree programme for MChem Chemistry with Industrial Training."***	***"Reduced fees of £4,500 for placements undertaken during the course of the 2012/13 degree programme for Mchem Chemistry with Industrial Training and Mchem Chemistry for Drug Discovery with Industrial Training."*** ***"Employability will be a University priority for 2013-14 and the particular needs of students from non-traditional backgrounds for support in finding appropriate placements and work experience will be a key focus."***	**South-West Spoke HEI. Bath Legacy Project focused upon the deeper embedding of placement schemes across the institution.**

[7] http://www1.aston.ac.uk/eas/research/groups/eerg/

University of Birmingham		***"Birmingham is setting up, from 2012, a STEM Education Centre, based in its College of Engineering and Physical Sciences, with a remit to build upon, and embed the legacy of the programme. Part of the Centre's activity will have a national focus on WP and Fair Access to STEM. We will do this as part of an agreed partnership with the National STEM Centre in York…"*** ***The tutorial system provides early indications if a student is experiencing difficulties and appropriate information, advice and guidance from the range of University support services (e.g. The Academic Skills Centre and Maths Centre)***	**Hosting of the National HE STEM Programme. The University also established a mathematics support centre through the Programme.**
University of Bolton	*"The University is committed to part-time, vocational and professional education; widening participation and extending educational opportunities to mature students and other under-represented groups; and to the teaching of, and research in, science, technology, engineering and mathematics, in particular."*		Active involvement by the HEI in five projects related to these themes. Three regional action plans, and two RAEng mini-projects. A research project through more maths grads focused upon part-time learning in mathematics.
University of Bradford	***"We lead the Northern Spoke of the HEFCE funded HE STEM programme designed to ensure universities work together regionally and nationally to widen participation in these key subjects. We have built on this role and through working closely with professional bodies we have developed a programme known as "Building STEM at Bradford".***	***"The University's STEM Centre will use existing best practice to support improved attainment though a range of activities with a focus on the hardest to reach communities and children from the most deprived backgrounds…"***	**North-East Spoke HEI. Adoption and development of a range of activities through the Programme.**

University of Central Lancashire	*"Students make a core contribution to many of our current outreach activities and UCLan has recently secured £53k from HEFCE to encourage STEM undergraduates, through an elective module, to develop and deliver outreach activities in schools and colleges."*	*"We are currently developing an elective module, which enables students to develop employability skills through outreach activities, made possible by an award of £53k from HEFCE through the HE STEM programme."*	A regional action plan project initiated through the North-West Spoke.
University of Chester		*"Building on pilots in STEM subjects, curriculum-related subject workshops with years 12/13 and level 3 students on "Preparing for University", with assignment follow-up and academic feedback; these can also be used to support progression to HE for work-based learner. An annual year 10 STEM Awareness week and continued investment in staffing and student resources, such as 'STEM Buskers' and 'STEM Ambassadors' will further relationships between the University, schools and colleges, as well as external industry organisations."*	Chester undertook a significant project through the North-West Spoke to establish self-sustaining STEM regional networks.
Coventry University	*"We wish to include in our Access expenditure a proportion of the costs of our Maths Centre which has been funded by several external sources including the HEFCE CETL funds."*	*"We wish to include in our Access expenditure a proportion of the costs of our Maths Centre which has been funded by several external sources including the HEFCE CETL funds."*	Mathematics support expertise at Coventry and Loughborough was rolled-out more widely through **sigma** within the National HE STEM Programme.
University of Hull	*"As part of our commitment to access we shall continue to charge a lower fee for Foundation Degree programmes which disproportionately attract students from under-represented groups".*		A Foundation Degree in the chemical sciences has been converted from part-time delivery to distance learning mode to enable participation by a wider cohort of learners. This has been extended to BSc provision.

Imperial College, London	*"....the Reach Out Lab was opened in 2010 to provide additional facilities to deliver practical programmes and an experience of university for pupils aged six to eighteen, specifically from schools without ready access to laboratories."*	*"The College will engage with other institutions and organisations where such collaborations will advance its mission and educational objectives…The College has sought to maximise the cost effectiveness and impact of its school outreach activities through strategic partnership with Exscitec, an organisation aimed at providing outreach STEM activities for widening participation and gifted and talented students…The College aims to at least maintain the number of pupils from disadvantaged schools gaining experience of hands on science activities through the Reach Out Lab."*	The Reach Out Lab formed a core component of the Practice Transfer Partnership to transfer this effective practice more widely across the HE STEM sector.
Keele University		*"Current undergraduate students are trained to deliver the Keelelink Ambassadors in Schools Scheme (KLASS)...this form of in-reach to schools will be retained, with expansion and development to complement other areas of focus under this agreement including specific 'Access to the Professions' sessions and STEM related sessions."*	Keele participated in three activities from the 'Menu of Activities' initiative, and has embedded these within the Keelelink programme.
University of Leeds		*"We will continue to support local young people in public care through an annual seven-month study support project working in partnership with other providers across the City, including Leeds Metropolitan University and Leeds City Council. In 2011/12 we further supported this group of young people through the National STEM HE project…This year the scheme also secured one-off National STEM HE Project funding to provide training to other HEIs on ways in which they could work more successfully with young people in public care."*	Participated in numerous activities through the National HE STEM Programme; reference is to the Looked After Young People initiative established by the North-East Spoke.
University of Liverpool		*"…and we also offer summer schools and Easter residential with an emphasis on STEM…Year 7 - activities linked to STEM and utilising our new state of the art central teaching laboratories, which will be made available to local schools to enable young people to take part in science activities on campus… we will offer bespoke activities for other schools, who can 'buy-in' from a menu which includes: overnight events, master classes, subject specific taster days, whole year group visits and bespoke events."*	Liverpool participated in three activities from the 'Menu of Activities' initiative, and led the regional RAEng outreach project.

Liverpool John Moores University		*"Other post-entry support includes Personal Development Planning (PDP), study support (including the setting up of a maths centre in recognition that numeracy issues can be a barrier to entry)…"*	Liverpool John Moores established a mathematics support centre through the Programme.
London Metropolitan University		*"Customised additional support on study and academic skills and in Maths and English."*	Liverpool John Moores established a mathematics support centre through the Programme.
Loughborough University	*"We will aim to increase achievement and interest in mathematics, science and engineering as well as providing additional mathematics support for our current students."*	*"We will aim to increase achievement and interest in mathematics, science and engineering as well as providing additional mathematics support for our current students."*	Loughborough forms a founding Partner of the HE STEM **sigma** Network. Two RAEng mini-projects are focused in this area, along with a large-scale curriculum innovation and enhancement project.
Manchester Metropolitan University		***"MMU was also the NW "spoke" for the National HE STEM Programme, a 3 year project ending in July 2012. There are a number of positive legacies from this engagement that the University is committed to embed and sustain in the future. In particular the Programme has enabled; closer working with HEIs in the region (such as The University of Manchester and Liverpool John Moores), enhanced Outreach offerings through investment in demonstrator equipment (e.g. Large-scale Maths Outreach and Conference Kits), and more strategic targeting of WP groups through comprehensive mapping of provision across the region. It has also facilitated much wider collaboration with local FECs and employers, which has enabled the development of new Foundation Degree provision, tailored training services to those in work and possible contributions to the Higher Apprenticeship framework."***	**North-West Spoke HEI. Adoption and development of a range of activities through the Programme.**
Newcastle University		*"Continue the delivery and further development of services that support students' academic skills post entry: Maths Aid and the Writing Development Centre."*	Maths Aid utilises the Numbas assessment system which was further developed through the Programme and made available nationally.
University of Northampton		*"Employability focussed programmes tackling gender imbalances will be run as part of the STEM agenda, e.g., Females into Computing, IT and Engineering."*	Participated in HE STEM Gender and Diversity training.

University of Nottingham	*"The Faculties of Engineering and Science run year 0 courses for a range of students, with the Engineering course particularly attractive to widening participation students. A new pre-entry bridging course is facilitating the entry of students without the normal mathematics requirements."*	*"The Faculties of Engineering and Science run year 0 courses for a range of students, with the Engineering course particularly attractive to widening participation students. A new pre-entry bridging course facilitates the entry of students without the normal mathematics requirements."*	A collaborative project has led to the embedding of a dedicated mathematics programme for Year 0 engineering students from non-traditional backgrounds.
Queen Mary, University of London	*"...we will continue to support the school through a range of activities including a one-to-one-mathematics tutoring scheme and a series of "maths challenge" activities..... Schools will develop and deliver an extensive range of widening participation activities in addition to the projects offered through the central widening participation team."*	*"We will continue to commit resources to collaborative work with charities and other external organisations involved in widening participation and access. This will include groups such as…Generating Genius, which seeks to encourage and develop talented students from under-represented backgrounds to aspire to professions in scientific research, medicine and engineering."*	Implemented a series of workshops to support students from Afro-Caribbean backgrounds to apply to read STEM subjects at Russell Group and 1994 Group universities.
University of Reading	*"Another already successful scheme that we will wish to support in this area is the outreach work entitled 'Chemistry the Next Generation' in the Chemistry Department funded by the Royal Society of Chemistry."*	*"Another already successful scheme that we will wish to support in this area is the outreach work entitled 'Chemistry the Next Generation' in the Chemistry Department funded by the Royal Society of Chemistry…Building on very successful outreach work in our Chemistry Department, we aim to extend the number of Teachers' Centres at the University and to drive further relationships with subject teachers in target schools/colleges, through the provision of continuing professional development."*	A direct legacy from the 'Chemistry the Next Generation' project. Further activities from the RSC pilot transferred to Reading through the Programme.
University of Sheffield	*"Our aim is to more fully integrate the academic and personal skills development activities that are already available, and to extend the numbers of student engaging with these opportunities. These include....MASH..."*	*"Academic skills support, including targeted and tailored maths support."*	MASH stands for Mathematics and Statistics Help. The University of Sheffield forms the North-East Hub of the HE STEM **sigma** Network.

Sheffield Hallam University		*Extend capacity for mentoring, peer support and buddying schemes targeted at those students identified as vulnerable to non-completion and/or drop out… During the past year we have also piloted the STEP scheme, an initiative to build additional mentoring capacity in Faculties through our alumni links.*	The mentoring scheme involving alumni was establishing within the Mathematics and Engineering by the Programme.
University of Southampton		***"In order to ensure that under-represented groups such as male African-Caribbean's are encouraged to access our pre-application programmes, we are working proactively with a range of groups to take a targeted approach, for example with Generating Genius."***	**London & South East Spoke HEI.**
Swansea University		***"Increased delivery of high-level skills in science, engineering and mathematics (including workforce upskilling, employer engagement activity, and employer-led part-time degree provision initiated by the National HE STEM programme)"***	**Wales Spoke HEI.**
University of the West of England		*"An outreach programme supporting progression to STEM related careers."*	Undertook project to implement more coherent STEM strategy.
University of York	*"The York Maths Skills Centre has been set up to provide University-wide support for elements of maths learning..... A pilot programme providing support for first year students from subjects (in the sciences and economics) whose modules include, or require, elements of algebra and calculus, has been very well utilised and we plan to expand this service to meet some additional areas of identified need."*	*"The York Maths Skills Centre has been set up to provide University-wide support for elements of maths learning, independent of departments, but in conjunction with what departments already provide. A pilot programme providing support for first year students…has been very well utilised and we are expanding this service to meet some additional areas of identified need. "*	The Centre described was established directly as part of the National HE STEM Programme through the work of **sigma**.

Table 8.1: An Analysis of OFFA and Fee Plan Agreements to Explore National HE STEM Programme Linkages. Spoke Partners are shown in bold.

38. A number of the activities of the Programme also aligned with national policy drivers, and as such these too have significant implications for sustainability at an activity level:

"The STEM projects aimed to influence the nature of provision in institutions but over the lifetime of these projects the more influential policy change around funding HE, in response to changing political requirements and national economic challenges, has tended to dominate and in some cases has influenced project outcomes and direction of travel." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

39. The national importance of Access Agreements linked to a changed higher education funding landscape undoubtedly lead to increased prominence for the work of the Programme with schools and colleges, but at the same time there was the perception of a shift away from the importance of workforce development as a policy driver. Business-university interaction, however, remained a core theme despite a change of government, and this was emphasised in February 2012 by the Wilson Review. This aligned with an area where the Programme was particularly active including the development of the regional STEMBUG and BizzUP employer engagement portals:

"I wanted to congratulate you and your team on this Business Universities project and to comment on how welcome this form of initiative is…" Sir Tim Wilson, Comments on BizzUP Employer Engagement Portal

40. While national policy drivers impact upon the potential for sustainability, international events too can impact upon the sustainability, legacy, or strategic direction of an activity:

"the Nuclear Island project involved the engagement of employers with national agendas in construction, nuclear power and electricity generation and the project from its inception to its evaluation spanned a period of dramatic change in public and political opinion…Notably, the Labour Government was replaced by a Conservative and Liberal coalition which had a noticeable anti nuclear stance in May of 2010. Twelve months later, the Fukushima Dai-ichi nuclear disaster which resulted from a series of equipment failures and the release of radioactive materials following the Tohoku earthquake and tsunami on 11 March 2011 further swayed opinion against nuclear power plant construction." [Project Report, Nuclear Island]

"The Maths Communicators course, and a case study in it, was included in the Vorderman report[8] to government on the teaching of Maths in England." [Project Report, Embedding Accredited STEM Communicator Models, University of Bath]

41. In the case of Nuclear Island, the events at Fukushima provided a real life scenario and a focal point for discussion, and as such the prominence of the project was maintained. Further, Cogent Sector Skills Council secured additional funding from the UK Commission for Employment and Skills (UKCES) Employer Investment Fund to not only sustain Nuclear Island from April 2012 through to March 2014, but also to expand it to include learning packages for apprentices and employees.

[8] http://www.tsm-resources.com/pdf/VordermanMathsReport.pdf

Institutional Commitment

42. The September 2011 West Midlands Enterprise sustainability review conducted a survey of project leads asking them about the support being provided to their projects by their institutions. Of the 116 responses, over 90% indicated their institution had provided some form of support to their activities, either financial, in-kind, or both. While this was promising, the survey was undertaken at the end of Year 2 of the Programme, and for many projects this reflected the early stages of their work. Such statements also need to be within the context of the Programme's framework for initiating activities which specified they should demonstrate some form of an institutional commitment to their work.

43. Having institutions formally 'buy-in' to activities at their outset was deliberate as it indicates the universities themselves, especially if the contribution is financial, are valuing the work that is taking place and investing in it; they too therefore have a vested interest in ensuring that it succeeds. The Internal Sustainability Review also provided evidence of high-level buy-in at the outset of Programme activities, and identified this as an important contributory factor towards sustainability, not least because it ensured senior level awareness of the work taking place, but also so that they might become a personal champion for the activity.

"Buy-in and active support from academics, Vice-Chancellors and senior executives is crucial to sustaining workforce development activity." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

With activities now having concluded their Programme supported lifetime, it is now timely to explore whether such institutional support has been maintained throughout the duration of project activities.

44. There is evidence that not only has senior level support been maintained across a range of the Programme's activities, but that it was also an important feature for projects that sought to make and embed changes to the curriculum, or engage in new approaches to delivery, if they were to realise successful outcomes:

"Support from senior managers with the positional authority to facilitate change was identified as being a key factor in successful implementation. Their involvement took three forms: as project leads or team members; practical support by individuals external to the projects (e.g. Heads of School); and, support from those with university-wide responsibilities." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

"Overall where senior staff have engaged with projects there has been an improvement in approaches and understanding of the benefits of employer alliances." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

45. In terms of the specific support provided by senior members of staff, this has been offered in a number of differing ways:

"The project lead is also Chair of the university's Admissions' Committee. The PVC Education is on that committee, so he was able to arrange a meeting for the project officer with the PVC - the person who really mattered. The project lead demonstrated his commitment to the project by volunteering to do two weeks in the lab demonstrating." [Academic Member of Staff, Research-Led Innovative Teaching Experiments, Durham University]

"The faculty and departmental management team supported the project and helped to drive it forward by leading up publicity events, ensuring that the course was allowed to be developed and approved, allocating work-loading activities against the module leaders." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

46. Furthermore, there also exists evidence that senior members of staff, perhaps not involved directly with the activity at its outset, sought to understand its outcomes and then contributed to ensuring its sustainability:

"In Chemistry and Mathematics, there was a strong sense from the management teams that the meetings had been very valuable and were worth continuing with in the longer term. Money will be set aside in the school budget in future years to ensure that the meetings can continue." [Project Report, Industrial Advisory Boards, University of Leeds]

47. While there are many examples of senior level buy-in having a positive impact upon the outcomes of a project, there were also a very small number of examples whereby the support that was offered at the outset did not materialise during delivery:

"…institutional support and that of senior management in my faculty has been disappointing and I feel incredibly let down and hung out to dry…" [Project Lead]

In this particular instance, senior management support was required to enable essential changes to the curriculum for the activity to succeed; the need for such support was recognised and agreed at the outset. As a consequence, this project was unsuccessful and failed to draw down any funds.

48. Having senior management or institutional commitment to an activity at its outset is only one part of the process. Such buy-in then needs to be maintained throughout the lifetime of curriculum focused projects to help them realise successful outcomes.

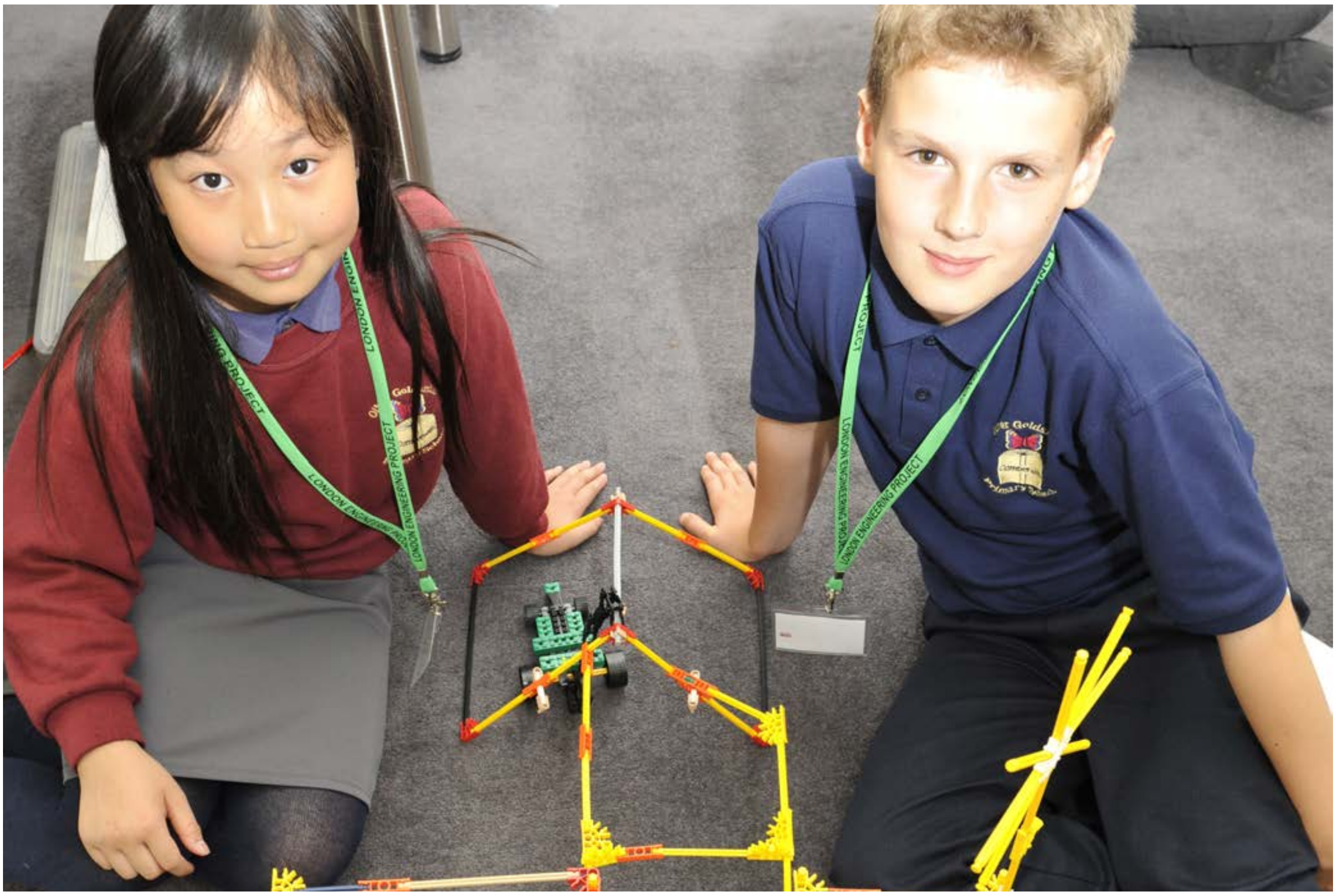
Evaluation

49. Evaluation is an important part of the educational enhancement process. As such, it needs to be embedded within an activity at its outset, in order to provide the data and evidence that not only allows the impact of an intervention to not only be measured, but also improvement to be identified:

"The evaluation data as discussed…indicates the knowledge that the students gained through all three workshops is highly valuable." [Project Report, Perceptions of Year 13 Afro-Caribbean Students to Read STEM Subjects, Queen Mary University of London]

"The learning from this project has enabled us to identify that student confidence and fear of rejection are two of the key factors which disengage them with the placement process; subsequently we are looking at innovative methods of working with student and employer mentors to build confidence in our students and empower them in their placement search." [Project Report, Undergraduate Placements: Smoothing Transition From Education to the Workplace, University of Brighton]

50. Throughout all stages of the project lifecycle, evaluation was an embedded feature, and as such project leads were required to ensure it received appropriate consideration; this was very similar to the requirement that sustainability be explicitly considered. In particular, all projects were required to discuss within their final case studies their approach to evaluation, and detail findings. Where a robust evaluation was not undertaken, this in itself was identified as a learning experience:



"No formal feedback was obtained from pupils during the day, but this in itself is a lesson that has been learnt from the event. Even if the activity does prove to be a one off activity, gathering information from the group in written format should be incorporated in future activities." [Project Report, Engineering Pick n Mix, University of Wales, Newport]

51. While evaluation was an embedded feature of the Programme's work, there is evidence that the timescale of the Programme, coupled with the longer-term nature of achieving and evidencing large-scale curriculum change, to an extent compromised the level of evaluation undertaken by some large-scale projects; for others, additional opportunities were explored instead:

"According to a number of those questioned, the National HE STEM Programme's funding period (2010-12) allowed insufficient time for the systematic planning, implementation and evaluation of large-scale curriculum change – especially when this was linked to external as well as internal accountability." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

"The team took a decision to pursue to learning opportunities provided by the touch-points and left the full evaluation, using appropriate qualitative and quantitative methods until the end of academic year – quite simply because of the opportunities provided by this project were too valuable to miss." [Project Report, Developing Graduate Employability Skills Through Industry Led Touch Points, University of Lincoln]

On the surface this may be a 'missed opportunity', but many of the larger-scale curriculum and workforce development projects intend to undertake their evaluations after the end of Programme support:

"The Lincoln RAPP intends to carry out an evaluation of the progress made and the programmes developed and Huddersfield is undertaking a more longitudinal study of the learners and employers engaged in the project, to assess the wider impact and evaluation of the developments." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

52. Throughout the final eighteen months of the Programme there existed a genuine desire amongst project leads to better understand and further engage with the evaluation process. In part this may have been due to Programme monitoring and reporting requirements, but there may have been other drivers. There is evidence of a changing emphasis across the sector in terms of reward and recognition for teaching focused staff, and a key requirement for the academic promotion of such staff is that they demonstrate engagement with scholarship in teaching and learning. Equally, the Programme operated in a changed financial climate, and for projects seeking to attract funds in a competitive environment for further development or extension, there is a need to demonstrate efficiency or efficacy over previous approaches.

53. With evaluation being a requirement for projects, a Programme-wide approach was taken to supporting project leads in the implementation of appropriate approaches. A working group, led by the North-West Spoke oversaw the development of resources, and the organisation and delivery of

workshops and events. The events provided support at a variety of levels: a number were focused upon practical approaches to undertaking a project-level evaluation, whereas towards the end of the Programme, the focus became upon supporting those who were wishing to develop a scholarly dimension to their practice through undertaking pedagogic research:

"I've learned lots of new techniques and being able to discuss their use in different situations has made me quite look forward to evaluating activities, something I never thought I'd say." Participant, Outreach Evaluation Workshops

"I found the 2 day workshop incredibly worthwhile and have left not only enthused to carry out pedagogic research but with an increased self confidence that this is something I can achieve." Participant, June 2012 Pedagogic Research Workshop

Dissemination

54. Dissemination is not only an important indicator of sustainability but it was also one of the priorities for the programme over its final year of operation. It indicates there is a 'story to tell', and reflects a belief amongst those leading an activity that there is valuable learning present that is worthy of being shared more widely, and it also has a potential to directly influence institutional practice:

"The emergent findings are in the process of being disseminated across the School of Engineering & Applied Science at Aston University via a newly developed Learning & Teaching Development Strategy. Additionally, plans are underway for the research to continue into 2012/2013." [Project Report, Regional Action Plan Projects, Aston University]

55. A wide definition of 'dissemination' was taken during the National HE STEM Programme, from encouraging project leads to present their work at workshops, conference and events, producing guides and toolkits, publishing details of their work as either case studies, articles, or academic papers, and, in a unique and innovative scheme, enabling the uptake of practices by offering successful projects for 'adoption' by other higher education institutions in order that the developed practices might become embedded elsewhere:

"One of the real innovative features of the Programme was the Adoption Scheme. I had never heard of anything like this being done previously, but it has meant the ideas and philosophies we initially developed are now far more widely embedded within the sector that we might ever have imagined." [Academic Member of Staff, Mathematical Modeling and Problem Solving, University of Leeds]

56. The 'Practice Transfer Adoption' scheme involved all ten Programme Partners identifying practices and activities that were sufficiently well progressed to have demonstrated success, that had potential for wider transfer across the higher education sector, and whose project leads were willing to support those from other universities to embed these activities locally. From a significant list, 25 projects were identified for 'adoption' that met the key criteria, and advertised to the higher education community in October 2011. The subsequent selection process of the 'adopter'

HEIs initiated over 80 instances of practice being transferred through this scheme. While these 'adoptions' were one of the last Programme activities to be established, there is already evidence that these have become embedded:

"A decision has already been made to embed public engagement activities into the Department of Engineering as part of staff development and student recruitment activities." Extract from: 'a meta-evaluation of the adoption of public engagement training activity at seven universities across the UK' commenting upon the adoption of the activity by the University of Wolverhampton

"In 2012–13 the centre will be open throughout term time for undergraduates…" Extract from sigma **final report 2013 commenting upon the mathematics support centre at the University of Warwick**

57. Those undertaking the activities of the Programme have also sought to disseminate their work through both presentation and publication. While such activities have been supported within the Programme structure, increasingly project leads have been disseminating through previously established external communication channels and networks and there is evidence this will continue:

"We have presented the website at Variety in Chemistry Education (Edinburgh, August, 2012) and at the HE STEM Conference (Birmingham, Sep. 2012). [Name removed] is further presenting to the RSC's Education Division Council in October 2012, where the future maintenance of the resource and effective dissemination will be discussed." [Project Report, Business Skills & Commercial Awareness for Chemists, University of York]

"The preliminary outcomes have already been presented to educators at the Farnborough Air Show and the final report will be presented to the Space Leadership Council and the HE STEM conference." [Project Report, Enhancing HEI Engagement with the Satellite Industry for Workforce Upskilling, University of Reading]

58. Exploring the participation of project leads in national learning and teaching conferences in 2012 also demonstrates a commitment towards the ongoing dissemination of learning and findings. At the first Higher Education Academy STEM Conference in April 2012, nine project leads submitted, and had published, papers describing their work[9]; at the 2012 CETL-MSOR Conference[10], which has been running within the higher education mathematical sciences community since 2006, twenty-one sessions were based upon Programme projects, and a number were offered by individuals who had not previously attended this conference series. At the Variety in Chemistry Education/Physics Higher Education Conference 2012[11] in August 2012, twelve sessions were offered by project leads, and at the Engineering Education 2012 conference[12] the Programme was represented through 11 paper presentations.

59. Dissemination through printed publication has been another ongoing feature of the work of the programme; and further ensures a legacy for its work by making available a range of resources to either influence or inform future practice, or provide an evidence based starting point for the

[9] http://www.heacademy.ac.uk/events/detail/2012/academyevents/STEM_annual_conf

[10] http://mathstore.ac.uk/conference2012

[11] http://vicephec.ph.ed.ac.uk/2012/programme

[12] http://cede.lboro.ac.uk/ee2012/

development of new activities and approaches. Examples include special editions of existing newsletters[13] and journals of learning and teaching[14], to guides and toolkits:

"Take advantage of the Toolkit produced by the EC. Seeing everything that needs to be considered/achieved in one place is very helpful and ensures that details are not overlooked." [Project Report, Engineering Gateways PTP, University of Greenwich]

I have been looking for something with practical tips for helping dyslexics with maths and there's not a lot out there so this really fills a gap. It's also helpful to have a relatively brief and to-the-point document to be able to give to colleagues." [Academic Member of Staff, University of Cambridge]

Professional Development

60. For the legacy of the National HE STEM Programme to continue to be felt long into the future, then it not only needs to impact upon the practices of institutions or leave behind a range of resources, materials and learning, but it must impact upon the individuals who are engaging directly with current, and future cohorts of learner. As such, professional development is an important part of the sustainability process and vital for developing longer term capability within the HE sector.

61. The collaborative nature of the Programme's activities has provided natural opportunities for professional development:

"Not only has it been an absolute pleasure, but also a fantastic professional development opportunity to be able to meet with and share ideas with teachers of A-level chemistry from across the region each teaching a different specification or in a different environment." [Project Report, Teacher Fellowship Scheme, University of Leicester]

"…several members of staff in each of the partner institutions have been engaged in the project work, as a result of us all running internal staff development events, and talking nationally and internationally on our project work. These staff have contributed by developing their own modules." [Project Report, Education for Professional Engineering Practice, Sheffield Hallam University, Loughborough University and London Metropolitan University]

[13] http://mathstore.ac.uk/headocs/MSORConnections113_0.pdf

[14] http://www.aldinhe.ac.uk/ojs/index.php?journal=jldhe

62. Similarly dissemination activities have been structured to provide both formal and informal opportunities for professional development, including project leads mentoring others through the implementation of activities during the 'Practice Transfer Adoption' Scheme, the **sigma** advisors scheme, whereby experienced practitioners provided advice and mentoring to those embarking on the provision of mathematics support, and the Programme's Professional Body Partners supporting individuals within the higher education sector to adopt and embed the practices developed through the four disciplinary pilot projects:

"Training is planned to prepare academic staff in particular to assist them with the development of courses for commercial clients." [Project Report, A partnership for Engineering CPD, Learning, Training and Knowledge Exchange, University of Bath]

"The course has been extremely relevant to my role within [Name removed] and has enhanced my ability to function as an education Business Links coordinator…I will be offering my services in delivering careers adviser training sessions on STEM to colleagues." Course Participant, Accredited STEM Careers Module

"Good for gaining ideas on small changes I can make to my practice that may make a bigger difference".Course Participant, Gender Equality Training

"However, there is no doubt that the [postgraduate] students who participated in this training event have learned a lot of useful skills that they are now using to good effect." [Project Report, Extending Your Outreach, University College London]

Developing a Community Identity

63. Creating a sense of belonging within an academic community can add real value to the work of an individual. It provides an opportunity to share examples of effective practice, benefit from the developments of others, share resources and materials, and most importantly gain support from like minded individuals; this alone can greatly aid or enhance the sustainability of an activity. If individuals obtain direct benefit from their time investment, these networks are likely to be self sustaining and can lead to the development of communities of practice.

64. Networking and bringing individuals together was an embedded feature of the Programme, and the 'Collaborative Projects', Menu of Activities' 'Practice Transfer Partnerships', and 'Practice Transfer Adopters' initiatives were all structured around this theme:

"The help of the practice transfer partnership in the form of its members and the draft tool kit have been very useful in developing the documentation and strategies to manage the programme once it is running." [Project Report, Engineering Gateways PTP, University of Derby]

"The seminar I attended brought all the relevant people into one room. In a few hours I was brought up to date on curriculum options and qualifications that I could use in the UTC to be opened in a few months' time. I could make critical, informed decisions."
Principal designate of an aspiring UTC, University Technical Colleges PTP

'…in that sense it has not felt very disparate; we are all contributing our expertise.'
Member of IoP Higher Education Group commenting upon Conceptual Understanding in Physics Project

65. The sustainability of the networks and collaborations established through the programme will be discussed later within this section of the report, but the approaches utilised within the Programme have become embedded within the practice of higher education institutions who have participated actively in its work:

"A cross-institutional Education seminar has been established and will continue to run this academic year, reporting on Education-related projects across a variety of disciplines to share best practice. A new in-house Academic Practice journal is being launched in Autumn 2012 and there is a sharing practice wiki under development."
[Academic Member of Staff, University of Exeter]

Wider Value

66. While the vast majority of the HE STEM completed projects have achieved their original aims and objectives in full, some have achieved wider impact; this might be in addition to their original intentions or due to a changed approach. In addition to the original activity itself becoming sustainable, other sustainable changes to the practice of HEIs might result:

"This project started out to simply add in a new MSc to the Department's portfolio. Unexpectedly, it has offered the opportunity to completely rethink our Postgraduate provision in Engineering. In addition, although we have not been able to start all the paperwork yet, it has informed us on how to deal with potential WBL provision at the Undergraduate level, which was definitely one of the key objectives of the project."
[Project Report, Engineering Gateways PTP, University of the West of England]

"These touch-points have led to a step change in practice within both the business and the University. The most immediate impact is that the School of Engineering is immediately able to accredit some of Siemens internal courses... This win-win situation encourages further collaborations and ensures that the touch-point programme will be sustainable beyond the life of this project." [Project Report, Developing Graduate Employability Skills Through Industry Led Touch Points, University of Lincoln]

Up-Front Investment

67. 'Up front investment' might be best referred to as 'pump-priming'; activities becoming sustainable because the substantial investment, either financial or human, is made up-front to either develop a product, revise the curriculum or implement a particular approach. Once this is complete, subsequent costs for delivery are much lower and the activity often continues through institutional support:

"In terms of sustainability the consensus amongst those interviewed was that those changes that have resulted from National HE STEM Programme funding, which have already become embedded in the curriculum will continue to be supported out of the teaching and learning budgets allocated to Schools." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education commenting upon the Programme's projects at Loughborough University (2013)

"Although circumstances have prevented the piloting of modules from that would make up the new hybrid degree courses, the groundwork has been done for their implementation including: the design/validation of the new course(s); the appointment of new academic staff; and, reaching agreement with a significant number of industrial partners." [Project Report, The Hybrid Part-time MEng Degree, Lancaster University]

"…there is a sense that the initial hard work will be worth it in the end, with a course that will almost 'run itself'" [Academic Member of Staff, Applied Physics, University of Portsmouth]

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68. Where resources or materials have been developed, the evidence shows that these will continue to be used, not only by those who developed them, but also by others who have subsequently benefited from their use:

"The boxes and kits will be very valuable to our maths department and central outreach teams." [Academic Member of Staff, University of Portsmouth]

"To date, seven of the eight trial teams have completed their case study reports and have indicated that they will continue to use the materials again in the next academic session" [Project leads for RSC C/PBL, Dublin Institute of Technology]

"The very positive reception the videos have received from our programme participants on the Learning and Teaching in HE programme mean that the University will continue to use the staff-facing videos in this and other staff development contexts, and the College of Engineering, Mathematics and Physical Sciences continues to make good use of the videos on their webpages for potential students. Since embarking on the project, the College has put significant additional resource into video-based material promoting STEM subjects at Exeter…" [Project Report, Becoming a STEM Enthusiast, University of Exeter]

"As a result of this project, the college now has a suite of marketing materials which it can use and develop on an ongoing basis to engage with females, BME or otherwise, to encourage them to choose engineering careers." [Project Report, Model for Engaging Women within BME Populations into HE Engineering Programmes in East Lancashire, Blackburn College University Centre]

Proven Starting Point

69. The approach of building an activity upon previously successful work elsewhere is one that has worked to great effect within the Programme.

"The HE STEM programme's approach in continuing to support existing centres of expertise is likely to support the development of the knowledge base." Evaluation of HEFCE's Programme of Support for Strategically Important and Vulnerable Subjects, HEFCE (2011)

This way of working was defined at the outset of the Programme, and has been firmly embedded throughout all activity strands. Such an approach is quite likely to result in sustainability as the impact of the activity is known in advance, and is likely to have been the reason why others are interested in undertaking it. There can never be a guarantee of success, but prior learning is known and advice and guidance are available to support others with implementation. The learning curve is therefore less steep, and successful implementation can often be realised more quickly.

70. Activities that follow this approach are often built around collaborations or interactions with others. Other examples of successful Programme led and established collaborations include the wider roll-out of mathematics support centres, the IoP and Durham University led Industrial Group Projects, context and problem based learning, where the proven starting point rested within the RSC, and Virtual Experiments at the University of Southampton which was extended to six further higher education institutions through the 'Practice Transfer Adoption' scheme.

71. The vast array of work established through the National HE STEM Programme and the efforts of those who not only led activities but also strived to try and understand its impact and capture key learning, now provides the unique proven starting point for others wishing to develop similar activities within the future.

Further Evidence of Sustainable Activity

72. Section 12 of this report contains a number of short case studies, derived from the reports provided by project leads, which represent a 'snapshot' of the work of the Programme. These exemplars represent only a sample of the Programme's activity as its scale means all projects cannot be

represented here, although some represent collections of activity around a particular theme. The included case studies have been structured so that they demonstrate both the outcomes from the Programme's work, but also the legacy that has, or will, result.

73. The focus adopted by the Programme to enabling sustainable activity within the higher education STEM sector was through seeking to embed it within core departmental practices and provision:

"All three SHU mini projects are being implemented and embedded into the teaching curriculum across the courses in the engineering portfolio. E-portfolios with an academic tutoring system will be embedded from Sept 2012. LSBU projects are being embedded in the first year programme and Loughborough support systems are also being embedded." [Project Report, Education for Professional Engineering Practice, Sheffield Hallam University, Loughborough University and London Metropolitan University]

"The project work has enabled the activity undertaken here to become embedded in the host department with several sources of funding being obtained to further the developments pioneered here." [Project Report, User-driven Photonics Skills Improvement via Life-long Learning (UPSKILL), Bangor University]

"Statistical literacy materials have been embedded within one of our courses (aimed at environmental science students)…We ran a 15 credit course on the Plymouth University PGCAP course (for new University teachers) entitled 'Teaching Statistical Literacy'. Six people have completed the course." [Project Report, Enhancing Workplace Statistical Literacy, Plymouth University]

"The Design Management Programme will be sustained at least until 2015, becoming part of other knowledge transfer activities and providing a template for the development of further projects." [Project Report, ENGAGE - STEM Work Based Learning and Employer Engagement, Cardiff Metropolitan University]

74. What appears to have contributed towards this success is allowing, and supporting projects to develop and identify their own sustainability plans before the activity is initiated. This allows projects to 'own' the future of their activity, and ongoing interaction from the Programme Team enabled them to ensure these plans are then put in place:

"However, the HE Group at the Institute of Physics has provided an important context for discussion about the Project, and served to ensure that it is embedded within the HE Physics community." [Academic Member of Staff, University of Leicester]

75. While activities initiated by the Programme will continue unchanged within a number of HEIs, others have committed to building upon the work as part of their own practices; this further reinforces the value of the project and may yield an even greater future legacy:

"We plan to continue to offer a semi-structured opportunity to STEM students during 12/13 and work towards the original vision of an accredited module, perhaps through attachment to the UCLan Advantage - our student experience package launched for the new academic year." [Project Report, Stand Out STEM Students, University of Central Lancashire]

"We plan to build on the success of these events in the following ways…" [Project Report, Hands on Maths Workshops, Brunel University]

"For future trips, we intend to make more of this session…" [Project Report, Talent2030, University of Warwick]

"Going forward we plan to apply the resources, learning materials developed and use our experience to:

1. **Roll out programme/variation of the course to a wider group of chemical companies…**
2. **Approach the Royal Society of Chemistry for accreditation."**

[Project Report, Accredited, Bite Sized Learning to Upskill Chemical Industry Employees, Anglia Ruskin University]

76. Further, examples exist of the Programme's work having a wider, and perhaps unexpected influence upon the activities of higher education institutions:

"The project also supported an institutional review of the frameworks available at the university (which allow for workplace learning to be recognised), and evaluated them following their use so that a new framework proposal could be prepared. Whilst the final framework was not concluded or approved within the project timescales, a large number of recommendations for the framework have been made as a result of this project." [Project Report, Is Accreditation of In-house Training a Flexible and Responsive Model for Up-skilling STEM Staff?, Northumbria University]

"The uptake of the toolkit by Schools extended beyond those involved in the original work included; Psychology, Biosciences and Earth & Ocean Science. Each requested a copy to aid their placement programme framework and also to train recently hired placement officers." [Project Report, Embedding Employability in the Student Experience of STEM Undergraduates: a Placement Toolkit for STEM Schools, Cardiff University]

"We are considering putting an element of our Outreach activities, specifically the Spectroscopy in a Suitcase project that we have rolled out from Durham, as part of the REF return." [Academic Member of Staff, Durham University]

Sustainability at 'Sector' Level

77. One of the key features of the work of the Programme is that it has sought to develop and undertake delivery of its activities in a collaborative manner building upon effective practice, existing expertise, and networks:

"Using HE-STEM, Engineering Council and Royal Academy research and employer engagement expertise, the Project built on established industry networks developed through HEFCE's West Yorkshire Lifelong Learning Network (WYLLN) Advanced Engineering and Manufacturing (AEM), professional institutes, national Sector Skills Councils and industrial training organisations. [Project Report, Succeeding in Tomorrow's Engineering World of Work, University of Huddersfield]

78. Where networks or communities of practice did not previously exist, some project leads identified the establishment of these as successful outcomes at the start of their work, for others, they developed naturally as a consequence of the activities taking place:

"One of the features of this current project was to investigate practice within the south west region and through setting up a network, offer the opportunity for practitioners to learn from each other's experiences." [Project Report, Peer Assisted Learning: In and Beyond the Classroom, Bournemouth University]

"These meetings have allowed us to disseminate our findings with a wide range of individuals, start to establish networks of those people involved in employer engagement, and garner support for the project aims." [Project Report, Integration of Understanding of Offerings for Engagement Between Higher Education Institutions and Industry, University of Exeter]

79. A question requiring consideration is whether the networks and communities of Practice established through the Programme will be sustained, and if so how? There is also the separate, but related question of the longer-term future of pre-existing networks with which the Programme aligned its activities, and to which members of the higher education community continue to contribute. Given such networks existed independently of the Programme, and as such, their sustainability is independent of its work, this is not the place for this question to be considered. Nevertheless, it remains an important issue requiring consideration.

80. Evidence exists that where networks were established to bring benefits to the activities of a higher education institution, particularly on a regional basis, these will be sustained:

"The University of Chester takes an active role in a number of networking groups across the region...Continued commitment to these networks and partnership working with employers, other universities and colleges provides the necessary support for collaborative bids for new sources of funding for future developments and the sustainability of STEM at the University." [Project Report, Self-Sustaining STEM Networks, University of Chester]

81. Additionally, where individuals have collaborated on activities of mutual benefit, they have indicated a commitment to further develop these links:

"The final steering group meeting has identified several areas of the joint STEM project for taking forward as a continuation of the group's work with suggestions for funding." [Project Report, Education for Professional Engineering Practice, Sheffield Hallam University, Loughborough University and London Metropolitan University]

"The network of part-time course providers formed during the project is a valuable outcome. It is already clear that it will be sustained as further collaborations have already started." [Project Report, Part-time students in the workforce, Coventry University]

82. There is evidence of thematic networks established throughout the Programme remaining active across the sector. For example, the STEM Disability Group[15] is continuing its work, coordinated by Royal Holloway London and supported by the Institute of Physics, and the Writing and Communicating in the STEM Disciplines Special Interest Group remains active out of the University of Bath. Both have an active online presence, and events scheduled well into 2013.

83. In other instances, mechanisms were put in place before the conclusion of projects to align network members with existing organisations in order that the networks established might continue as part of a larger grouping:

"Participants will be encouraged to join the jiscmail.ac.uk/ldhen discussion group and, to join the Association for Learning Development in Higher Education." [Project Report, Peer Assisted Learning: In and Beyond the Classroom, Bournemouth University]

84. In maintaining the activeness of existing networks across the sector, the CFE evaluation identified two mechanisms:

"The professional or scholarly bodies, which were integral to the pilot projects as well as the subsequent Programme, have been identified by many as an appropriate means through which to continue to support HE STEM developments across the sector well into the future…The other body, whose mission aligns with elements of the Programme, is the Higher Education Academy (HEA)." CFE, Summative evaluation of the National HE STEM Programme (2013)

[15] http://www.rhul.ac.uk/ecampus/welfare/disabledstudents/stemdisabilitytransitiongroup.aspx

The contribution of Partners to maintaining the legacy of the Programme's work will be discussed further in Section 9, but specific examples are relevant here given maintaining support for national disciplinary activities aligns with the institutional missions of the Professional Bodies involved in the Programme. For example, the RSC will maintain the Spectroscopy in a Suitcase network, and the IMA will coordinate the network of institutions hosting the regional MLOCK outreach kits. Similarly for the IoP:

"The Institute of Physics will continue to support the group of co-ordinators at the universities. The group have begun to discuss other joint areas of interest, such as laboratory classes." IoP Representative, Industrial Group Projects

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Similarly the relationship developed between the Programme and the National STEM Centre will be maintained through a three-year national Programme of activity funded by the University of Birmingham. It is intended this will help maintain and develop interactions between higher education institutions and existing STEM organisations and initiatives with a view to the enhancement of university led widening participation and outreach practices.

85. While many of the Programme initiated networks will be maintained, it is important to note that some beneficial activities associated with the networks may not:

"…each of the regional hubs has identified mathematics and statistics support practitioners who are willing to take sigma **network activities forward after that date in order to ensure that they continue to operate as a means of developing and sharing good practice. Nevertheless, funding is urgently needed to build on what has already been achieved by the** sigma **network, particularly to support the pedagogic research on which on-going improvements in professional practice can be based." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)**

Section 9:
Legacy and Learning

Introduction

1. The aims and objectives that the National HE STEM programme set for itself over its three year period of operation were designed to be deliberately challenging. The Programme was a large scale initiative, the largest single Strategic Development Fund project supported by HEFCE at the time, with a wide remit, and building upon four previously successful projects that were well respected and valued by their disciplinary communities. The Programme needed to be ambitious. Its purpose was not only to disseminate the learning from these pilot projects within the higher education sector, but to embed them within institutional practices. At the same time it needed to maintain the higher education STEM sector's focus upon the importance of continuing to widen participation, and take forward a new agenda relating to higher level skills, not only for those who were soon to graduate, but for those within the workplace as well. The Programme also needed to do achieve this without duplicating the work of others, and in a manner that would ensure its activities were sustainable in the higher education sector. A 'direct delivery' model was not an option, the Programme's work need to be led by the higher education sector and firmly embedded within it; as such this ambition was not only justified, but necessary.

2. Being deliberately ambitious, however, posed challenges for the Programme in terms of how it would articulate the impact of its work:

> **"There was wide recognition even as the Programme was being established that its deliberately ambitious aims, particularly those relating to widening participation and changing institutional practice, would be difficult to measure." CFE, Summative Evaluation of the National HE STEM Programme (2013)**

Further, with the focus of the Programme being upon changing practices and approaches in a sustainable manner this would always be hard to measure and quantify:

> **"It can be argued…that the aims of the Programme were not suited to simplification into an easy to measure quantitative framework. Influencing institutional practice by its nature will vary from situation to situation and cannot necessarily be standardised and measured." CFE, Summative Evaluation of the National HE STEM Programme (2013)**

3. One of the significant challenges the Programme faced throughout its period of operation was demonstrating that its work was having an impact while it was underway, and this is perhaps an area where the Programme struggled most. In being unable to demonstrate progress towards objectives, particularly during its early stages, there were negative perceptions of the Programme and its approach. As members of the Programme sought to collect evidence of the impact of their work, this perhaps took the focus away from the delivery of other activities which further compounded this effect.

4. It must also be remembered that the Programme did not set out to solely deliver a range of interventions, its perspective was upon trying to embed positive changes that would enhance the activities of higher education institutions in their approaches to recruiting students and delivering STEM programmes of study. This in itself requires a longer-term approach, both to implement and to evidence.

5. With the Programme having concluded its funded period some months prior to the production of this report, there is access to an increasing array of evidence and information, both internal (produced by the Programme and its projects) and external (from the CFE and initial West Midlands Enterprise evaluations and Synthesis Reports), as to the impact of its work and the legacy that it will leave. This section explores the legacy that the Programme has left for, and within, the higher education sector.

Examining the Evidence for a Legacy

6. The Programme's March 2009 proposal to the funding councils identified a series of outcomes (Box 2.6) that, if realised, would indicate a successful Programme with a legacy for the higher education STEM sector. The preceding sections of this report contain a range of evidence and information demonstrating just some of the sustainable changes that have been made to the practices of higher education institutions and the influence it has had upon those who work within them. It is appropriate to explore just how some of this evidence 'maps' relative to these successful outcomes proposed in the March 2009 proposal.

An increase in the number of young people within the STEM disciplines in HE including those from traditionally under-represented groups

An increase in the number of adult learners within the STEM disciplines who, in particular, engage with part-time provision

7. Table 9.1 has been compiled from the most recently available data, provided freely by the Higher Education Statistics Agency (HESA)[1], and shows student enrolments on higher education courses by subject area and mode of study in the period 2007/08 to 2011/12. While 2011/12 was known to be a year of high enrolment prior to the changes to student fees, both part-time and full-time student enrolments for the STEM disciplines have consistently performed better than the sector as a whole over this entire period. It should be noted data is available showing participation patterns by ethnic group, but it is not routinely available by discipline and so an analysis of this area (or by gender or disability) is not currently possible using the freely available information.

8. While the Programme operated over a three-year period beginning in August 2009, it did not become operational until February 2010 when it commenced the process of establishing its activities. In reality, the activities of the Programme to influence learners would not themselves have commenced delivery until the 2010/11 academic year at the earliest, which would mean that, even at best, any students influenced by the Programme's work would not have started higher

[1] http://www.hesa.ac.uk/content/view/1897/239/

education study until 2011/12, the very last year represented by these figures. The Programme therefore, cannot claim that this increase in student numbers is a causal effect of its work.

	2007/2008		2009/10		2011/12		% Change	
	FT	PT	FT	PT	FT	PT	FT	PT
Physical Sciences	52,685	11,655	57,190	14,340	62,860	12,200	19%	5%
Mathematical Sciences	22,770	6,225	26,225	7,465	29,065	8,180	28%	31%
Engineering & Technology	80,425	23,335	89,480	23,885	95,725	24,300	19%	4%
All Science Subjects	**556,580**	**202,650**	**598,305**	**216,225**	**632,230**	**198,120**	**14%**	**-2%**
All Subjects	**1,232,005**	**572,965**	**1,333,900**	**580,810**	**1,411,975**	**516,165**	**15%**	**-10%**

Table 9.1: Student enrolments on HE Courses (% Change is 2007/08 to 2011/12)

9. However, it is certainly true to say that the pilot projects themselves were operating over a period that could have influenced these figures, as were a range of existing STEM organisations with whom the Programme successfully worked. While it is known other factors can influence student study choices, for example the media, it does appear apparent that the collective work of the STEM community, both during and preceding the Programme, will have had some positive causal effect upon student study patterns in STEM.

10. This 'delay effect' the time between any intervention and a student, full-time or part-time going on to study in higher education, along with the fact that many other factors, positive and negative, can affect study choices, reinforces the challenges of using such data as a quantitative measure of impact.

An increase in the number of learning opportunities within the STEM disciplines for those who wish to engage in study on a flexible or part-time basis

A greater role for employers in shaping the STEM provision offered by HEIs, particularly in relation to the development of their workforce

11. The work of the Programme has created new full and part-time programmes of study in chemistry, engineering and physics (discussed in Section 6), and a whole range of shorter courses or units of study for those who wish to access components of higher education level learning (Section 7).

12. In physics, Applied Physics degrees have been established at the Universities of Bradford, Portsmouth and at St Mary's University College, and Integrated Sciences has also been implemented at the University of Bradford. In engineering, 5 new 'Gateways' type degrees have been created in conjunction with the Engineering Council at the Universities of Coventry, Derby, Greenwich, West of England and Leeds Metropolitan University. A new part-time Bachelors and Masters level programme, delivered by distance learning, is also available to engineers in the workplace from the University of Bournemouth. At the University of Hull, a part-time degree by distance learning is now accessible to those wishing to study chemical sciences.

13. At Swansea Metropolitan University, two new programmes have been established. A part-time programme of study, which was also implemented at Glyndŵr University, recognising prior

workplace experience allows students to enter a part-time Bachelors degree at Level 5 alongside more qualified students. A part-time programme was also established in Materials Engineering to complement existing provision offered by Swansea University and ensure the availability of a full suite of qualifications for the steel industry within Wales. At the University of Wolverhampton, a two-year manufacturing degree will commence in September 2013 with its first cohort of learners.

14. An analysis of the 2012/13 data when available might reveal the impact of the Programme on both full-time and part-time learners, particularly if considered at an institutional level. For example, it is known, and was discussed in Section 6, that a number of STEM students are registered for, and progressing within, full-time and part-time courses or modules of study that were established as a result of the Programme's work. While some were active in 2011/12, many came online for 2012/13, and others are scheduled for first recruitment in 2013/14. Given the additional capacity that these courses have generated within the STEM sector, and given that students are actively participating within those that are underway, it does not seem unreasonable to conclude that the Programme has influenced, and contributed to an increase in, student participation within STEM although quantifying the extent of this influence will remain difficult if not impossible.

15. To support and encourage those currently within the workplace to engage with STEM learning more bespoke options have been established, including allowing learners to access between 10 – 30 credits of university level learning via a range of study modes, or non-credit bearing short courses. Such flexible provision, discussed in Section 7, has been established within 17 universities (Bolton, Plymouth, Manchester Metropolitan, Southampton, Central Lancashire, Salford, Liverpool Hope, Cardiff Metropolitan, Swansea Metropolitan, Northumbria, Huddersfield, Bangor, Anglia Ruskin, Reading, Greenwich, Sunderland, Gateshead College, and Teesside). Innovative provision

was also developed at the University of York for those wishing to engage in STEM lifelong learning; one of the first participants on the course won the 'York 2012 Adult Learner of the Year' award.

16. One of the barriers identified to university-employer engagement within STEM is that employers can find it difficult contacting the appropriate department or accessing information within a university when seeking to initiate collaboration. A number of universities sought to develop mechanisms to address this through the Programme; for example, Weymouth College implemented a new client relationship management system and Manchester Metropolitan developed a regional 'Gateway'. Such changed processes and practices will lead to enhanced future engagements long beyond the conclusion of the Programme.

STEM programmes within HEIs that provide opportunities for undergraduate students to engage with those in the school and employment sectors, and provide increased opportunities for wider skills development

17. By engaging with the Programme, many higher education institutions have been able to review and revise their curricula to provide increased skills development opportunities to their students. Employers have contributed to these revisions as either advisors, for example through the many industrial advisory boards that have been established, or have contributed to the design, delivery, and assessment of the curriculum, such as at the University of Lincoln or through the Nuclear Island project at Imperial College London. Universities have been supported to make changes to their curricula in a manner appropriate to their needs; some have implemented significant curriculum revisions, for example at Nottingham Trent across chemistry, physics, forensic science and computing programmes, others have revised their laboratory courses within a discipline to focus upon 'skills, discovery, and projects' as at Durham University, while for some employability and skills have been made a key focus of their provision, for example at the Universities of Leicester and Salford.

18. Students themselves have been encouraged to engage as active participants in managing and developing their own learning. The student led projects model from Imperial College has been developed and transferred to a further eight universities. At six universities, students have reviewed the undergraduate curriculum within their discipline area and identified recommendations as to how departments can better help them develop essential skills; many universities have, or intend to, act upon these recommendations. Through a variety of models, students have contributed to enhancing their skills and supporting the learning of others through peer assisted learning. Innovation has been seen in this area. For example, the Maths Arcade, which started at the University of Greenwich before being transferred to a further seven universities, and through the use of student interns at Loughborough University to revise undergraduate modules in conjunction with academic members of staff.

19. Embedding more interactive forms of teaching into the STEM curriculum has taken place within a number of universities. Nine higher education institutions have engaged in problem based learning activities in physics, and 22 in chemistry. In both cases, a further range of 'off the shelf' resources have been developed, and these have joined those developed by the Stimulating Physics and Chemistry for our Future projects in being made freely available to the sector; the potential impact of this work is therefore most likely greater. Approaches to helping students develop mathematical models and solve problems, which first started within the School of Physics and Astronomy at the University of Leeds, were transferred and embedded with a further 12 STEM departments over

the course of the Programme; a further outcome is that an ongoing national network has been established and the activities have been modified to engage schools and colleges.

20. Opportunities for undergraduates to engage with employers have increased within the higher education STEM sector. In physics, the Industrial Group projects initiative began in nine universities before the Programme concluded; 10 further physics departments will also implement the scheme in 2012/13. At the University of Teesside, three employers now have 'company sponsored' modules embedded within the undergraduate curriculum, and at the Universities of Cardiff and Bangor there are opportunities for students to work with employers on the development of enterprise skills across a range of programmes; in both Universities the extent of this provision is expanding to make it available to a wider range of learners. At Sheffield Hallam, students are now running a small company undertaking computer aided design work for local businesses.

21. At the Universities of Birmingham, Bath, Aston, Nottingham Trent, and Leicester, undergraduates now have the opportunity to work on interdisciplinary projects designed by business and industry, either as credit bearing components of their courses, or as additional extra-curricula opportunities for skills development and enhancement. Employer led mentoring schemes have been established at Sheffield Hallam University and the University of Huddersfield, while at Coventry University part-time students with industrial experience are mentoring full-time students; furthermore, this scheme has been transferred to three further universities. Placement schemes, utilising a variety of models, will now be more common across the higher education STEM sector following the work of the Programme with notable changes at the Universities of Reading, Brighton and Bath, as will engagement with SMEs following initiatives at the Universities of Southampton, Bangor, London South Bank, Cardiff Metropolitan University and Weymouth College for example.

22. As well as increasing student engagement with employers, postgraduates and undergraduates are now working with local schools and colleges within many universities to help inspire and motivate future generations of STEM learners. Accredited STEM communication models are now in place at the Universities of Bath, Chester and Bristol, mathematics busking schemes have been implemented at the Universities of Manchester and Leeds, and a physics busking scheme is in place at Aberystwyth University. Supporting and encouraging undergraduate and postgraduate students to become STEMNET Ambassadors has been a feature of the Programme's work across all regions and disciplines, and in an innovative scheme, the Universities of Bath, Exeter and Plymouth have embedded approaches to enable ambassadors to better develop and articulate key employability skills.

Increased and sustained engagement between regional HEIs leading to a collaborative approach towards increasing and widening participation within the STEM disciplines

The establishment of strong and sustained regional links between schools, colleges, FE, HEIs and employers with a streamlined and targeted approach to increasing and widening participation in the STEM disciplines

Increased ownership by those within the HE sector of activities to increase and widen participation within the STEM disciplines including the successful integration of the activities of the four existing HEFCE funded Pilot Projects and the activities of others

The activities and resources of the HEFCE pilot Projects are embedded within the HE sector and the work of other national initiatives and organisations

23. There is a strong track record of collaboration and shared working within the higher education STEM sector. This was previously fostered through the work of the four disciplinary pilot projects and the activities of the (then) Higher Education Academy Subject Centres. While it perhaps might have been expected in the changed higher education 'landscape' of recent times this culture might no longer hold true, the Programme has shown that not only are collaboration and sharing perhaps stronger than ever, but it has also been able to demonstrate the benefits to higher education institutions in doing so.

24. Collaboration has been embedded throughout the Programme across all strands of activity; over 80% of projects involved collaboration to some degree. Not only have collaborations developed between individuals and universities who had not worked together previously, but opportunities for joint working have been enabled with those outside of the higher education sector, including a range of employers, STEM organisations and initiatives, and those within the third sector. The inclusive approach adopted by the Spoke universities to developing their activities has encouraged universities to collaborate on an enhanced basis at regional levels, and the transfer and embedding of pilot project outcomes has result in national, regional and disciplinary joint working.

25. The RSC's Spectroscopy in a Suitcase initiative now forms a national network across England and Wales with 21 higher education institutions participating, and several sharing equipment across a region. In mathematics, the Spectroscopy in a Suitcase model has been replicated with the establishment of Mathematics Large Outreach Kits based within 19 universities but shared on a regional basis. Large collaborative outreach projects were established in the Programme's Spoke regions to transfer and embed the learning from the London Engineering Project. These projects established a collaborative and integrated approach to outreach and widening participation with a legacy of enabling university staff and students to engage in such activities more effectively; over 30 higher education institutions participated. The national **sigma** mathematics support network has been established with the creation of a hub in each Spoke region to act as a focus for the sharing of learning, resources and expertise; through the **sigma** Network 45 universities have been able to participate in national mathematics support activity. While established independently of the Programme, the Stimulating Physics network now provides a collaborative mechanism that enables the on going transfer of effective practices from the Stimulating Physics project into schools.

26. In implementing the outreach activities developed by the four pilot projects, universities have collaborated to undertaken these within local schools. The Universities of Kent and Canterbury Christ Church are now collaborating on Engineering outreach activities having done so for the first time through the Programme, and in the East Midlands the Universities of Leicester, Loughborough, Nottingham, and Nottingham Trent, along with AstraZeneca delivered chemistry outreach activities

utilising the East Midlands Science Learning Centre. In London and the South East, the University of Southampton worked with National Grid and the regional Science Learning Centre to provide professional development opportunities to enhance their knowledge of engineering careers; the model has influenced the future practices of both National Grid and the Science Learning Centre itself.

27. Universities have worked closely with existing STEM organisations to enable complementary activities that have brought added value. Collaborations with STEMNET focused around staff and student ambassadors have occurred within all of the Programme's regions and across all of its disciplines, and universities have engaged with STEMNET STEM Clubs to enable sustained opportunities for working with hard to reach cohorts to be embedded. In the North East, the Looked after Young People project has embedded within many of the regional institutions as a way of working involving the STEM disciplines, and with the implementation of activities taking place through partnership working. Teacher Fellows have worked with the Programme on both a regional and disciplinary basis; working with STEM departments, the combined knowledge has enabled university practices in working with schools and at the transition to be changed, and enhanced relationships spanning the sectors have developed as a result.

28. The Universities of Chester and the West of England have developed new strategic approaches to working with regional schools and colleges to enable sustained engagement, and in the North West an integrated approach has been taken to providing professional development opportunities to allow those currently within the workforce to enhance their knowledge and skills. In London & South East, the Universities of Southampton and Queen Mary are now working with Generating Genius to support Afro Caribbean boys and other underrepresented groups of learner; this work has been further expanded through a donation made by Google. Across the Spoke regions projects to enable universities to work with third sector organisations were established and continue their activities in 2012/13 as part of an ongoing national community of practice, and through the RAEng, an ongoing community has been established to support those universities working to establish University Technical Colleges.

29. There is evidence across the Programme's work of appropriate targeting to ensure school and college focused activities engaged hard to reach cohorts. One mechanism of achieving this has been by enabling universities to work with existing STEM organisations on focused and targeted activities, while in others academic staff from STEM faculties and departments have worked with members of central institutional teams. While not all targeting approaches may have developed as a result of the Programme, the legacy is that higher education staff now have the expertise and future contacts to continue these targeting mechanisms as a means of reaching widening participation cohorts. In this vein, the professional development of higher education staff and students has taken place through collaboration. A series of professional development events were undertaken to support enhanced outreach and diversity practices, while the Programme's

workshops and events have allowed developed practices to influence the ideas and approaches of others. In this regard, capability and knowledge within the higher education STEM sector has been enhanced and can continue to be applied long into the future.

Increased awareness of those within HEIs of the work of others in relation to higher-level skills and widening participation built around an effective and efficient approach for the sharing of effective practice in these areas.

30. The Programme's delivery model has enabled it to not only share effective practices that have resulted from its activities, but to ensure that existing successful approaches were successfully incorporated into its work. The interactions between Programme Partners at regional, disciplinary and national levels enabled priorities to be identified, and collaborative solutions implemented that built upon effective practices where they existed. Activities were sometimes identified through open calls, where individuals established their own collaborations, managed calls, where higher education institutions responded to undertake work in priority areas from which collaborations were then built, and brokered opportunities, where collaborations were established, encouraged, or insisted upon to work on specific activities and priorities.

31. Dissemination was a core part of the Programme's work to ensure the sharing of learning generated, and this occurred at a number of levels. Events and workshops were held nationally, regionally, and within individual higher education institutions; publications, resources, and toolkits were developed. There is evidence of how participation in Programme events, or the use of developed resources, has either influenced individuals to engage with the Programme, or implement new ideas and approaches. Where the success of the Programme is most evident, however, is in how it has sought to extend the nature of 'dissemination' to encompass 'uptake'; that is, it has established mechanisms that have proved particularly effective at enabling approaches developed in one university to be adapted and transferred to another.

32. The Menu of Activities initiative offered pump-priming funds, implementation guides and materials, and most significantly access to the expertise of those who had previously undertaken the activities, as a means of transferring and embedding a number of the practices and approaches developed through the four disciplinary pilot projects; 65 activities were successfully completed by universities through this initiative. Evidence from 51 of these projects is that they will either be sustainable or they have resulted in some form of practice change. Eight large-scale partnerships were transferred to share and embed effective practice in the key strategic areas of outreach and working with schools and colleges, diversity, retention, careers, work-based learning, and University Technical Colleges (UTCs); there also exists evidence these Practice Transfer Partnerships have impacted upon higher education sector practices. Another approach was developed whereby 'seed funding' was made available for others to implement approaches that had been presented at the Programme's workshops and events or contained within its publications. This was a simple concept, but it has resulted in a number of instances of successful approaches to enhancing undergraduate skills and university assessment practices within the mathematical sciences being transferred between universities.

33. Perhaps the most innovative scheme established through the Programme has been the Practice Transfer Adoption initiative. Through this scheme, the leads of successful projects with potential for transfer were asked if they wished to make their projects available for 'adoption'. Other universities would then submit proposals to adopt, adapt and embed the activity and in doing so receive a costed level of resource that was typically significantly less than that originally needed

to develop the activity. The existing project lead would themselves receive a level of financial resource, up to a capped value, to support the new universities with the embedding of the activity. Through this initiative, over 80 Programme developed practices have been transferred between universities with already many examples of successful outcomes.

"…it has become apparent that what is really needed is support from a trainer, rather than money to help fund the event." [Project Report, Effective Evaluation of STEM Outreach PTP, National Co-ordinating Centre for Public Engagement]

"This HE STEM project has clearly demonstrated that it is possible to introduce teaching initiatives into HE so as to achieve changes in practice that have national impact and the potential for sustainability with modest units of funding. Indeed, on reflection, I doubt if our project would have had quite the same impact if it had received £300k under the 'old rules and formulae'!" [Project Report, Mathematical Modelling and Problem Solving, University of Leeds]

The development of a national model for engagement and delivery that is self-sustaining, self-propagating and firmly embedded within the core practice of HEIs

34. This final outcome was perhaps always going to be the most challenging for the Programme; both to implement and evidence within its three-year funded lifetime. Achieving this outcome was made even more challenging by the changes to the political, economic and educational landscape within the UK over the Programme's period of operation.

35. There is now comprehensive evidence, internal and external, that the substantial majority of the activities established through the Programme will be sustainable, and as such continue beyond the end of its funded lifetime. Not all activities will exist in their original form; some will be modified while others have contributed to changed practices and approaches within the universities that implemented them.

36. Furthermore, there is increasing evidence that individual projects are continuing to build upon their work in some way, either through additional developments, or by their wider roll-out across a faculty or university to encompass new programmes or discipline areas. Examples can be seen in the projects at the University of Leeds, the University of Wolverhampton and the Nuclear Island initiative who have all secured additional funding to build upon, or extend their work. In Section 8 of this report, the sustainability of the networks and collaborations were discussed, and the available evidence suggests that many of these will be maintained as those involved recognise the benefits of collaboration. However, while the networks continue, some of the beneficial activities with which they were associated and that occurred through the Programme, for example the educational research associated with the **sigma** network, may not, without the availability of additional funds.

37. One question that perhaps requires consideration, is to what extent has the Programme impacted upon institutional culture and practices beyond the STEM disciplines with which it has engaged?

"Although the Programme does seem to have influenced practice and activity at institutions, we have found less evidence of wider cultural change at institutions. The sphere of influence of many projects was restricted to the activities or individuals closest to the project, rather than influencing wider institutional culture." CFE, Summative Evaluation of the National HE STEM Programme (2013)

38. The preceding sections of this report present a number of examples where projects have commented that their work has exerted a wider influence upon their institutions including those outside of the six Hub and Spoke partners. A key feature is the role of university staff within this process:

"The introduction of team based projects is new to the faculty (with an exception in Food Science). Whilst this is not new universally, it is a new teaching style for Maths, Chemistry (and Physics) and the project funding has enabled us to develop a rigorous methodology which has given confidence to the execution of the module design. Whilst there are pockets of the University that are actively engaged with employers, this is new, and so the way we have built the relationships with employers will provide useful advice (and supporting documentation) for others." [Project Report, Engaging with Employers to Enhance Employability in Mathematics Graduates, University of Leeds]

"The staff have been developed through it too; it has opened their eyes, it is going to be rolled into other years. It is prompting discussion across the university." [Academic Member of Staff, Building Effective STEM Graduates, Nottingham Trent University]

"The support and interest we have received from academic staff in favour of what we are seeking to achieve has been fantastic, and has signalled the beginning of a unified front between placement staff and academic staff which is an excellent platform for us to build from." [Academic Member of Staff, Undergraduate Placements: Smoothing the Transition from Education into the Workforce, University of Brighton]

"The project has been sustainable – the project will be over but staff have learned such a lot that will embed approaches within the curriculum. We will not be able to recreate the programme but it will be easy to take lessons learned forward. The Head of the Teaching and Learning development unit had early involvement with project and further evaluation next year may result in further T&L developments." [Academic Member of Staff, Making Maths Graduates More Employable: An Enhanced Role for Tutors, University of Greenwich]

"…because the Legacy and Steel Academy project team are enthusiastic, they have been sending staff information about other video materials and it has both become a conversation piece and a catalyst for changing the teaching style. Fears that using video lectures would result in a drop-off in attendance, have been unfounded. Informal networking is a powerful but undervalued technique." [Academic Member of Staff, Swansea Metropolitan University]

39. However, this is perhaps another area where it remains too early to tell. The Programme was established with four STEM disciplines firmly as its focus, and as such its natural emphasis was to embed sustainable changes in terms of how universities recruit students and deliver programmes of study within these disciplines. There is comprehensive and compelling evidence this has been achieved within a large number of higher education institutions at departmental and faculty levels. While these four STEM disciplines are strategically important and vital to the future of the UK and its economy, in the largest universities they represent perhaps only 10-20% of its overall provision. As such, it is therefore perhaps not surprising that wider cultural change is not demonstrable, particularly given the timeframe over which the Programme operated:

"It is beyond even the most optimistic perspective that institutional change would be embedded at the end of the lifetime of projects. It is perhaps fairer to consider how small changes have occurred and been led from a department or a faculty level and consider how projects may be able to use their experiences to stimulate interest beyond their own limited field. The STEM projects have demonstrated ideas and developments that have been picked up both within the institutions and outside and in some cases 'adopted' by other similar departments or faculties in other HEIs." Kettle & Smith, Lessons Learned and Achievements from the Regional Action Plan and Legacy Projects (2013)

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40. Bringing about significant change at an institutional level takes time to occur, and perhaps even longer to document and evidence. It might therefore be the case that the work of the Programme has started this process of wider institutional change. Such a statement should perhaps not be surprising as the Programme has undertaken significant activities within a number of higher education institutions. A number of these projects have received senior management support in some form; the projects have engaged with individuals who are well placed to bring about such wider cultural change.

41. There is another consideration; to effect wider cultural change there perhaps needs to be a critical mass of individuals committed to furthering the enhancement of institutional learning and teaching practices:

"The changes in teaching and learning that were discerned are not the product of top down management-led reforms, but the result of actions taken by individuals and groups with an awareness of the need for change combined with the ability to draw on their 'innovation capital' in order to create and implement imaginative solutions to problems relating to the curriculum." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

Such a 'critical mass', coupled with senior management support presents the start of favourable conditions into which a culture of change can be introduced within higher education institutions.

42. The Programme established a large number of activities within the higher education sector. In excess of 80 universities have led projects, and if each project is considered as a discrete element, they sum to over 500. However, this does not give the full perspective. Many projects were related, some forming applications of a particular approach at another University, others were sub-projects of much larger initiatives.

[While there was an] "even spread between a large number of smaller projects and decreasing numbers of higher value projects… Several stakeholders commented that the large number of small projects may have limited overall effectiveness, because it is more difficult to achieve a transformational impact on the practice of a university through a smaller project." CFE, Summative Evaluation of the National HE STEM Programme (2013)

43. There existed a strong rationale for the Programme offering a number of smaller value projects which remains valid. It was necessary to enable inclusivity, particularly with so many STEM departments seeking to engage with the Programme, and to allow individuals to develop and test ideas. Transferring effective practices between universities, which was undertaken extensively, also requires significantly less resource than it does to enable new approaches. Equally, it was important to provide opportunities to those who had not previously led projects to do so:

"Projects leads had varying degrees of experience in such a role – for some this being their first experience of managing an externally funded initiative… Participation in the development activities associated with projects funded by the programme therefore, provided both individuals and groups with opportunities to work within 'communities of practice' and in so doing further their own professional development. In particular, they were able to improve their skills in: bid writing; project planning and management; report writing; evaluation; and, dissemination." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

44. As a consequence of this approach, a number of universities had multiple Programme projects; in particular, 5 non-Spoke universities had over 15 projects each (Loughborough, Leeds, Sheffield Hallam, Coventry and Liverpool). While to an extent this might already reflect the culture towards supporting teaching and learning activities within these institutions, but the number of projects within any one institution indicates the development of a group of committed individuals who can contribute to wider institutional changes.

45. There is further evidence that the Programme might have started to stimulate wider cultural change, but also reinforces the conclusion that it may still be too early to tell:

> **"Despite the view held by some stakeholders 'that the best is yet to come' with the regard to the impact of activities funded by the programme, there was broad agreement that the following outcomes had been achieved: much critical reflection about teaching and learning; enhanced understandings of student learning needs for life and work in a 'liquid age'; new ways of engaging with students and supporting their learning; improved feedback to learners; opportunities for staff development; wikis that offers ideas and advice; improved team working in relation to curriculum design and delivery; and, practitioner networks (or 'communities of practice') within institutions and across the HE sector." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)**

Evidence of a Legacy Amongst Programme Partners

46. Where evidence of a longer term commitment to engaging and working within the higher education STEM sector can be found however, is amongst the six Spoke and four Professional Body Partners who comprised the Programme Team. Each has articulated plans of how they intend to continue working in support of the higher education STEM sector. For the Programme's Hub and Spokes, it must be noted, however, that this is separate to the continuation of any disciplinary activities that may have been undertaken by individuals from these institutions as part of the Programme's work.

47. At the University of Birmingham, which formed the Programme's Hub and the Midlands and East Anglia Spoke, a STEM Education Centre was established on the 1 August 2012. While this Centre will also have a remit to support STEM education within the University, it also has a national, externally facing remit to support the continuance of the Programme's work. At a practical level, this includes the ongoing publication of learning emerging from strands of the Programme's activities, including guides produced by individual projects, and of which a number have either already been made available or are currently in preparation, and ensuring that resources and project reports remain accessible through the Programme's website.

48. The Birmingham STEM Education Centre will also undertake national projects. A collaboration has been agreed with the National STEM Centre to further promote and encourage school, college and university engagement. This builds upon the relationship the University established with the National STEM Centre throughout its development and operational phases and will work to help higher education institutions to engage collaboratively with existing STEM organisations. The Centre is also undertaking a national project with the Higher Education Academy to support staff who wish to undertake pedagogic research, and to explore the school-university transition within the STEM disciplines. The national activities on pedagogic research are being undertaken jointly with the RSC, and the activities on the school-university transition with **sigma** at Loughborough University.

49. Also as part of its commitment to furthering STEM working at a regional level, the University of Birmingham is now STEMNET's sub regional partner for the Birmingham and Solihull region, and hosts the Further Mathematics Support Programme's Area Coordinator. The University has also recently announced that it intends to establish a University School and Sixth Form with a student intake from September 2014; the school will have a natural STEM focus.

50. At the University of Bath, support and leadership continue to be provided to the National Communities of practice project, established in conjunction with AccessHE. As part of this commitment, the University continues to lead a regional community of practice focused upon enhancing STEM outreach practices with local Somali communities. The University also maintains its active role as the regional Hub of the **sigma** mathematics support network; an event on accessible resources for mathematics was held at the University in January 2013.

51. At Manchester Metropolitan University, the University not only hosts the STEMBUG Gateway, but has committed to its further development with the addition of enhanced features. The University also hosts one of the regional Mathematics Large Outreach Kits which is available for loan by other higher education institutions, and the North West Science Learning Centre, based at the University, continues to make available bespoke training for university staff and students to enhance their outreach practices.

52. The University of Bradford has established the Building STEM@Bradford programme with support from the Higher Education Funding Council for England. This development includes a new STEM laboratory for use with schools, and once this opens in 2013, it will provide a mechanism for the ongoing delivery of both outreach activities and teacher professional development opportunities within the region. The University has continued to foster the relationships it has developed through the Programme with a range of STEM organisations, and continues to support the Sustainable Laboratories (S-Labs) Conference and Awards; the 2013 conference is scheduled for June at the University of Liverpool.

53. The University of Southampton, through its Access Agreement, has committed to continued working with the charity Generating Genius, while Swansea University, through its Fee Plan Agreement, has committed to maintaining its increased delivery of higher skills provision established through the Programme.

54. The Programme's Professional Body Partners have committed to maintaining many of the networks established. The Royal Academy of Engineering is working with higher education institutions engaged with the University Teaching Colleges initiative through seminars, professional development sessions and by engaging with awarding bodies to ensure appropriate curricula are available. It will also continue to publish reviews of evidence for impact in STEM outreach, widening participation and diversity, and undertake evaluations to define best practice. Within the mathematical sciences, the activities of the **sigma** network have been sustained by its regional hubs, and this will mean that the CETL-MSOR conference continues for an 8th successive year. The IMA maintains overall coordination of the Mathematics Large Outreach Kits based across England and Wales, and continues to host and develop the Mathscareers website.

55. The IoP, in addition to continuing to support the work of the Stimulating Physics Network, is maintaining support for the network of Industrial Group Project providers, those implementing new or repackaged physics degrees, and the STEM Disability Transition Group which it jointly leads with Royal Holloway, University of London. An extension to the Conceptual Understanding in Physics project has also been initiated in partnership with the University of Leicester on quantum mechanics.

56. The RSC has committed to continuing to support the Spectroscopy in a Suitcase scheme for the foreseeable future; this includes the provision of online services to aid universities with implementation, and co-ordination of the national network of practitioners. Funding was secured from the Higher Education Academy through its Open Educational Resources initiative to collect further resources, and ensure those developed through the Programme are made available through its Learn Chemistry portal. The online undergraduate skills record is maintained for use by students, and biannual meetings of School Teacher Fellows continue to be supported on a STEM-wide basis.

A legacy of Learning

57. While much of the work of the Programme was focused upon developing and embedding new approaches, a number of projects sought to try and better understand observed phenomena by undertaking research with a view to enhancing future practice. In particular, educational research was a key strand of the RAEng's work within the Programme. As a consequence of such activity, the Programme has collectively increased knowledge within the STEM sector, and most importantly this work forms the basis for informing the activities of others in the future.

58. At the University of Leicester, for example, a project was undertaken in conjunction with four other Universities (the Universities of Birmingham, Loughborough, Coventry and Aston) to explore the reasons why a number of engineering graduates remain unemployed sometimes many months after graduation. The findings from the project were submitted to the House of Lords as part of its 2012 Inquiry into Higher Education in STEM Subjects. While the report noted no single reasons for the unemployment of engineering graduates, it identified steps that they, and their universities, could take to improve their chances of securing a graduate level engineering role shortly after graduation.

59. Following on from the London & South East Spoke's Audience Segmentation Study, which identified various factors that can encourage or dissuade minority groups at different educational stages to study science and work in industry, a University of Southampton research study was undertaken with Nurturing Talent. Nurturing Talent is a widening participation initiative targeting able young people in the Somali community in Brent, North London. The project followed the progress of Nurturing Talent over the course of a year of its operation, identifying elements of best practice, making suggestions for future improvements and producing a good practice guide for use by those within the higher education sector who might be planning to engage in similar activities.

"We have found that Somali youngsters do aspire to go to university, and their parents are similarly keen for them to progress to HE. However, there are a number of significant barriers potentially preventing them from doing so, including: misconceptions about who goes to university and what it's for; lack of knowledge of UK universities and where they are; limited advice and shared experience from teachers at school; deficiency in parental knowledge of the UK education system; limited involvement of religious/community leaders; lack of suitable role models, among others." [Project Report, Changing Perceptions of Higher Education Amongst hard to Reach Groups, University of Southampton]

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60. While some projects have undertaken educational research, others have captured valuable learning through the evaluations that they have undertaken. As discussed within Section 8, the Programme placed a particular importance on all projects undertaking a robust evaluation of their work, not only did this help guide and inform their activities, but it has also generated an array of learning of

effective practices and approaches that can offer a further legacy to the sector and form a starting point for the work of others:

"The research identified some notable examples of projects in which evaluation had played an important role in providing evidence of impact and furthering the development process." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

61. While the Programme provided significant support to the evaluation and research activities of its projects, not all accessed this support, and across the sector, further work remains necessary if full value is to be extracted from other similar educational projects in the future:

"However, evaluation could have been used more widely and effectively had its role been better understood and its potential recognised." Tolley et al., Investigating Longer-Term Curriculum Change and Institutional Impact within Higher Education (2013)

62. While only a starting point, this reinforces the value of the work currently being undertaken by the University of Birmingham, the RSC, and the Higher Education Academy in this area:

"Beyond this there is interest for subject/disciplinary led research into curriculum change, i.e. bringing together staff in Physics departments to undertake research into learning, teaching and assessment. This focus upon pedagogic research within disciplines is a key development need, and one that has been taken forward in the USA, but represents a gap within the UK context, even though it is allowed for within the REF." [Project Report, Conceptual Understanding in Physics, University of Leicester]

Emerging Evidence: Influencing the Approaches of Others

63. While there is evidence of the impact of the work of the Programme within the higher education sector, it is only now that evidence is beginning to emerge of its impact on other organisations. While some evidence may be anecdotal, changes or approaches have been implemented by other organisations that appear to model themselves upon National HE STEM Programme practices. It will be interesting if, and what, other examples emerge in the future.

64. For example, in March 2012, the Higher Education Academy launched an open call for collaborative teaching development grants based upon cross-institutional and/or interdisciplinary collaborations. It also offered a further open call for such projects in

January 2013[2]. Furthermore, to support a series of workshops on social media in engineering and mathematics, workshop participants have access to small scale funding to implement some of the ideas and approaches they have witnessed[3]. Such a model was first implemented as a means of transferring practices within the mathematical sciences strand of the Programme's activities.

65. In December 2011 the Programme submitted evidence to the House of Lords Inquiry 'Higher Education in STEM Subjects'[4] for a report which was published in July 2012. The Programme was referenced on four occasions, two of which related to skills and the lack of employer involvement in establishing Quality Assurance Agency (QAA) benchmark statements. As a consequence, the QAA have approached a representative from the North West Spoke who undertook an employability skills review and invited them to join an advisory group to develop employer-led guidelines on the inclusion of skills and employability language, as used by employers, in the subject benchmark statements. These guidelines will be piloted in the review of some STEM Subject Benchmark Statements during autumn 2013.

A Legacy for Those Who Have Engaged

66. Throughout this report, one group who have not been considered are the learners who have engaged with the activities and work of the Programme. This has not been an oversight, the focus of the Programme was upon higher education institutions and those working within them to deliver STEM Programmes of study. In conclusion, it seems an appropriate point to consider the views of just a few of the students who have participated in the Programme's work.

"I have recently secured myself a place on Capita's System Integration graduate scheme, I have spoken highly about Grand Challenge and believe that it has helped me hugely in securing the place." Undergraduate, Grand Challenge, University of Birmingham

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"At every workshop I learnt something new so that was great, and every teacher [all were UWE STEM Student ambassadors] at every station made sense and was good." Student, Constructing a Coherent STEM Strategy with Schools, University of the West of England

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"Just wanted to pass a massive thanks on to you and the team for the brilliant quiz today... the students were in such high spirits on the bus back and it was very clear that being challenged as much as they were did them the power of good." Teacher, Pop Maths Challenge, University of Leeds

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"I found the project challenging and interesting. It made me feel as if my laboratory skills had really improved and progressed since A-level as we were actually planning the experiment ourselves." Undergraduate Student, Research-Led Innovative Teaching Experiments, Durham University

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"Associating with real students and gives you a view on university life and how they enjoy it. An interesting and learning afternoon" Student, Spectroscopy in a Suitcase

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[2] http://www.heacademy.ac.uk/tdg/collaborative

[3] http://www.heacademy.ac.uk/events/detail/2013/22_May_CLL_Social_media

[4] http://www.publications.parliament.uk/pa/ld201213/ldselect/ldsctech/37/37.pdf

"Working with the staff I found quite surprising at first because before the internship I was scared to ask a question in lectures because I thought I might be patronised but it turns out that working with the staff has changed my view on this and I now feel I can ask them questions." **Undergraduate, SYMBΩL, Loughborough University**

"At the start of the year I was planning to do an MSc in Economics, now I am applying for an MSc in Physics" **Undergraduate, Industrial Group Projects, University of Bristol**

"My perception of myself is that I know nothing about science and that science is hard and that I can't do it and I don't understand it and although that hasn't been completely eradicated it's, there's been moments where I think because of the content and because of Alex's [tutor's] presentation and if I may say so [another participant's] your additions to that in terms of making the link with everyday life, it's like made me realise that actually maybe this isn't beyond me, maybe this isn't as hard and as painful as I thought it was, and yes I do have a history, I have a difficult history at school with science and stuff… of course science has always been in a box way over there somewhere out of my reach on a high shelf. The box, the science box, has been moved down a few shelves" **Adult Learner, Connect to Science, University of York**

"I now possess a better understanding of the process of commercialising an idea and have developed an understanding of Intellectual Property, marketing techniques as well as general business practices. I also have a more thorough understanding of the type of companies that operate within the UK and can appreciate how the size of the business can affect the structure of it." **Undergraduate, Developing Enterprising STEM Graduates, Cardiff University**

"You helped me to pass this module; without you I wouldn't have done it" **Undergraduate Student, Mathematics Support Centre, London Metropolitan University**

Section 10:
Finance

Overview

1. The Programme's budget was first discussed within Section 2 of this report, where changes to it from that proposed within the March 2009 proposal to the Funding Councils were first described. In conjunction with the Funding Councils, the Programme's budget was revised on a number of occasions over its lifetime to take into account the underspend that had accrued and re-prioritise this towards additional activity. The last of these revisions took place following submission of the Programme's Business Plan in October 2011.

2. Within the Programme's Internal Sustainability Review (September 2011), a number of activities were highlighted that could be successfully extended or transferred and embedded more widely if additional financial resource were made available to Programme Partners; all partners were provided with the opportunity to propose such activities. The Year 3 Business Plan comprehensively reviewed the Programme's finances and identified financial resource that could be allocated. A list of proposed activities (Table 10.1) were developed and costed and these were submitted to the Funding Councils for sign-off.

Activity	Description	Agreed?
Applied Physics	Extend the Applied Physics degree to an additional university.	Yes
Industrial Group projects	Extend the Industrial Group projects initiative to a minimum of four additional higher education institutions.	Yes
Mathematics Support Centres	Establish an additional six mathematics support centres.	Yes
Interactive Outreach in the Mathematical Sciences	Make the Mathematics Large Outreach Kits (MLOCK) available to a lead higher education institution in each of the six Programme regions.	Yes
Enhanced Dissemination – Royal Academy of Engineering	Extend the dissemination of work undertaken through the Programme through production of a case study guide.	Yes
University – Third Sector Engagement	An Extension of the Community of Practice Model, developed in the South West, to all Programme regions through national rollout.	Yes
Workforce Development	Establish further legacy workforce development projects building upon existing effective practice.	Partially

Table 10.1: Year 3 Business Plan Extension Activities

3. With the exception of one, all proposals were agreed. While the Workforce Development strand was not agreed outright, a separate proposal from the University of Wolverhampton (Gearing up for Industrial Growth) was considered and for this funding was approved. There is no doubt that this decision to allow the re-prioritisation of funds through the Business Plan has allowed each of these projects to achieved significant additional impact. As a consequence of the revisions in the Business Plan, the Programme's resource allocation was reduced to £20,612,151 but this also reflected the fact that the Funding Councils were now overseeing the external evaluation process given its changed nature from formative to summative. Additionally, the Programme streamlined a number of its approaches in its final year, particularly in relation to its dissemination activities, and once a contingency had been excluded from these figures, its operating budget was £20,353,650.

4. The overall expenditure of the Programme is shown within Table 10.2.

Expenditure Item	Bid Budget	Total Budget	Total Spend	Variance
Core Activity Grant				
Staff costs	£8,871,416.00	£6,880,534.59	£6,778,849	**101,685.18**
Activity costs	£10,768,000.00	£6,750,014.78	£6,605,417	**144,597.61**
Other costs	£1,360,584.00	£598,171.27	£517,556	**80,615.00**
Total (Core Grant Allocation)		**£14,228,720.64**	**£13,901,823**	**£326,897.79**
Additional Activity Grants				
Legacy Projects		£902,053.00	£861,297	**£40,756.10**
Practice Transfer Partnerships		£579,638.00	£563,402	**£16,236.48**
Practice Transfer Adopters		£767,105.00	£717,805	**£49,299.98**
Regional Action Plans		£2,370,554.00	£2,253,882	**£116,671.57**
Centrally Funded Projects		£794,591.30	£703,651	**£90,940.30**
Additional Projects		£710,988.85	£796,109	**-£85,120.30**
Totals	**£21,000,000.00**	**£20,353,650.79**	**£19,797,969**	**£555,681.92**

Table 10.2: Overall National HE STEM Programme Expenditure

5. When the Programme's budget was revised, it was also presented in an alternative manner, significantly different to that contained within the March 2009 proposal. This allowed expenditure to be monitored more effectively and more regularly; 3 monthly financial statements were submitted to the Funding Councils through the Programme's Executive Committee. Making direct comparisons with the original budget is therefore difficult, but it is possible to consider the amounts spent on staffing and activity in particular relative to the original proposal.

6. Table 10.2 demonstrates that the Programme utilised £19,797,969 of its available resource; this represents an underspend of approximately 5.7%. Further, Figure 10.1 demonstrates the proportions of resource allocated to both staffing and activity within both the original funding proposal and in the Programme's final financial statement.

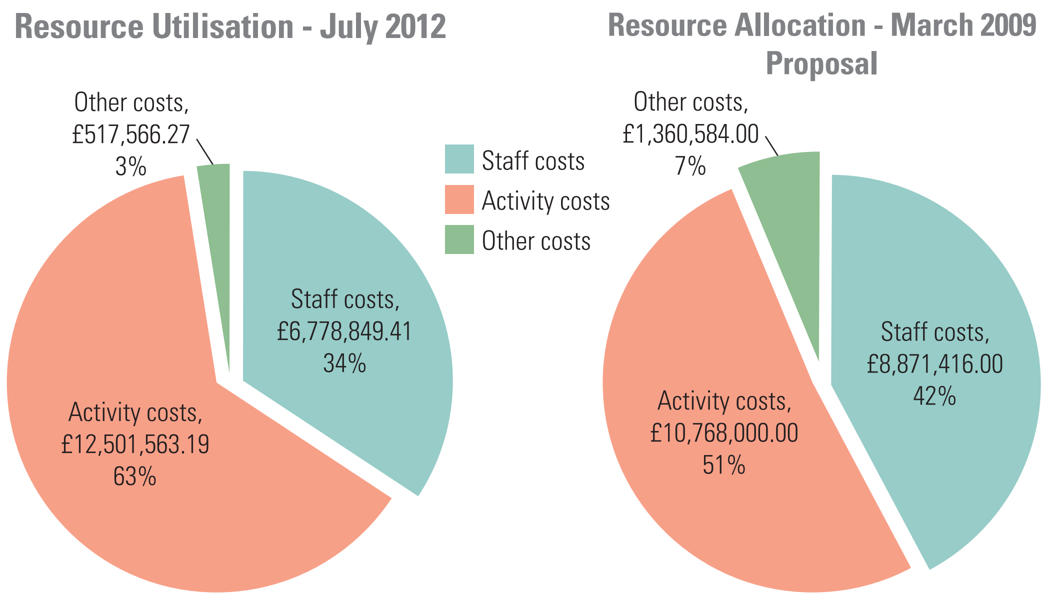

Figure 10.1: Proportions of National HE STEM Programme Spend on Staffing and Activity

7. What is evident is that through reprofiling its staffing underspend, and reducing other associated costs, the Programme was able to spend an additional £1.8m on activities within the higher education STEM sector. In the March proposal, 51% of its £21m budget was scheduled to be spent on activity, in July 2012, the actual proportion of the original £21m budget spent on activities was 59.5%.

Expenditure Item	Staff Costs		Activity Costs		Other Costs	
	Budget	Spend	Budget	Spend	Budget	Spend
Hub	1,033,743	1,035,178	814,805	554,927	142,000	164,040
RAEng	774,822	807,039	721,812	665,310	13,366	28,862
IMA	623,488	590,988	891,512	919,376		
IOP	366,500	354,620	1,238,500	1,211,600		20,967
RSC	366,323	375,227	995,726	983,195		28,597
Wales	524,827	527,822	471,792	455,099	56,006	34,985
South West	608,404	605,206	388,043	397,177	74,158	68,222
London and South East	520,355	509,898	445,895	483,799	61,617	31,938
Midlands and East Anglia	641,203	578,656	230,000	324,576	81,408	19,794
North East	819,774	775,156	169,150	222,127	81,722	55,733
North West	601,096	619,059	382,779	388,231	87,894	64,419
Totals	**£6,880,535**	**£6,778,849**	**£6,750,014**	**£6,605,417**	**£598,171**	**£517,557**

Table 10.3: Expenditure Breakdown by Programme Partner

8. Table 10.3 shows the breakdown of the original grant that was made to each Programme Partner. Additional financial resource was made available to Programme Partners through a series of mechanisms that have been discussed within this report to enable additional activities to be undertaken; details are shown within Table 10.4.

Expenditure Item	Legacy Projects		Practice Transfer Partnerships		Practice Transfer Adopters		Regional Action Plans		Centrally Funded Projects		Additional Projects	
	Budget	Spend	Budget	Spend	Budget	Spend	Budget	Spend	Budget	Spend	Budget	Spend
Hub			10,000	20,000	62,500	47,060	112,500	112,500	794,591	703,651	100,000	122,000
RAEng			165,171	157,113	82,500	82,500					30,500	35,500
IMA					88,600	88,600					170,489	170,489
IOP			52,500	47,864	58,030	57,414					190,000	190,000
RSC					18,100	18,100					-24,969	-24,969
Wales	154,835	134,283	90,000	68,558	50,000	37,500	367,041	307,693			40,000	39,139
South West	152,500	152,500	35,000	47,000	166,375	156,181	425,299	397,873			180,000	200,000
London and South East	149,133	136,429	81,167	70,547	64,000	53,950	344,156	339,437				
Midlands and East Anglia	149,835	144,865	80,800	87,320	64,500	64,500	241,038	223,169				
North West	125,744	123,214			25,000	25,000	450,520	443,211				
North East	170,006	170,006	65,000	65,000	87,500	87,000	430,000	430,000				63,950
Totals	**£902,053**	**£861,297**	**£579,638**	**£563,402**	**£767,105**	**£717,805**	**£2,370,554**	**£2,253,883**	**£794,591**	**£703,651**	**£686,020**	**£796,109**
Total Additional Activity	**£11,996,108**											

Table 10.4: Additional Finance Allocations to Programme Partners

Section 11:
Reflections and Recommendations

Introduction

1. In undertaking the work of the National HE STEM Programme a lot has been learned that might assist others who deliver similar large scale programmes of activity in the future. This section therefore comprises a series of reflective observations and recommendations addressing all aspects of the Programme's work. A rationale is provided to support each recommendation. To aid reading, recommendations have been grouped into related themes.

2. The reflections primarily relate to processes associated with delivering such a large scale, distributed, and collaborative programme of activity. These also exists substantial learning from across the range of Programme projects that needs to be analysed and considered further; while some of this work is already underway amongst Programme Partners, further follow-up forms the basis of one of the recommendations to ensure key learning, which is perhaps only now emerging, continues to be captured and made available to the higher education sector.

Recommendations and Rationales

Recommendation 1: 'Start-up' and 'stand-down' periods should be included for all similar Funding Council projects. While their duration might vary, for projects where the appointment of staff members are key to delivery, the start-up period should be a minimum of six months. The 'stand down' period should be at least three months, and should allow the project to retain some level of core staffing.

3. The most substantial challenge faced by the Programme was the almost non-existent start-up period prior to it commencing on the 1 August 2009. Not only did the Programme need to recruit staff, but it also needed to recruit Spoke Partners. This short timescale led to 'knock on' delays in establishing activity, and resulted in many of early challenges and tensions described within the CFE evaluation.

4. A 'start-up' period would not only allow contracts between project partners to be agreed (see Recommendation 9) but would also allow the recruitment of key personnel to commence prior to a project becoming operational. During this start-up period key processes and procedures, including communication and information management protocols, can not only be developed, but agreed

amongst partners. It allows the views of external stakeholders to be collected, and external advisory groups to be established. Most significantly, a start up period allows all Partners to influence the strategy and delivery approach of a project; this is important for successful delivery, but equally important this happens at the project's outset to avoid modified approaches.

5. A 'stand-down' period is also essential. With the ambitious aims of the Programme in terms of embedding changed practices coupled with a delayed start, Programme partners were left with a choice: either ensure their projects conclude around Easter 2012, or allow projects to continue beyond. Such a choice was a difficult one, asking projects to conclude early would have reduced not only development time, but also the time they had available to pilot interventions with students. This was made more difficult as 2011/12 was the time when most projects began to deliver their activities with learners. Furthermore, it would have meant that projects would perhaps have written final reports without having the full array of data and information available to them; without knowing whether activities have had a positive effect or not, this then limits the commitments that can be made to their sustainability.

6. All Partners chose, quite rightly, to allow their projects time to conclude in order to maximise the benefits of the investment in their work. Allowing projects to continue close to the end date of the Programme then led to the risk they might overrun, when Programme Officers would no longer be in post, or limited the time for analysing the work, preparing it for dissemination, and compiling any financial statements and reports. Once consequence was that dissemination activities became heavily concentrated into the final months of the Programme, perhaps leading to 'event fatigue'. As such, there was considerable work undertaken by all Programme Partners post-July when key staff were no longer available to conclude projects. It should be noted that reports for some projects were not received in final form until some several months after the conclusion of the Programme.

7. A 'stand-down' period would avoid such effects. A fixed activity deadline would provide a natural focus for when external projects need to conclude and report on their work, but then allows a period of several months where a level of staffing is in place to enable any outstanding matters to be concluded. This includes ensuring all outputs are appropriately captured and packaged for legacy dissemination.

Recommendation 2: Projects seeking to change institutional practices and approaches require a minimum period of operation of at least five years.

8. Establishing changed approaches and practices within higher education institutions is a longer term investment.

"...university programmes are reviewed in cycles (perhaps 3 years) with minor annual review of modules.....we are only now getting to grips with amending and supplementing resources, things like sustainability and continuation will depend in large part on how successful this initiative is seen to be in academic year 2011/12. We won't have exam results to compare with the current year until summer 2012. If they are really good we might have a chance of persuading some colleagues about adopting changes in 2012/13."
[Academic Member of Staff, HE Curriculum Innovation and Enhancement Projects]

9. For activities to become truly embedded, as has been demonstrated by the Programme, changes to curricula are required. Not only do these require time to develop, such changes often need to be submitted for approval some six months prior to the start of a new academic year. For a large-scale curriculum intervention, for example at programme or departmental level, it might therefore take two to three years before its impact upon students is known. If, further revisions to approaches are necessary these effects may not be evident for three to four years.

Recommendation 3: The importance of sustainability should be embedded within all projects and its progress monitored. In particular all Funding Council projects should be required to undertake a sustainability and impact review at some point during their period of operation.

10. For the Programme, the first evidence of its impact and sustainability became evident during the sustainability review undertaken shortly after the end of its second year of operation. The sustainability review was a helpful process for several reasons: it reinforced right at the outset the importance of sustainability and perhaps was the key driver in this subsequently permeating throughout all aspects of the Programme's work. It ensured that sustainability was a key factor in the establishment of activities, and ensured that it remained a focus for projects throughout. The sustainability review itself enabled specific evidence to be sought, and provided a mechanism by which judgments could be made regarding reallocating funds towards successful and sustainable activities.

Recommendation 4: While external evaluation should be embedded throughout the duration of a project to enable formative feedback, an external evaluation should continue for a period of time beyond its conclusion. For a Funding Council project of the scale of the Programme, this might be for an additional year.

11. A challenge that existed for the Programme throughout was the capture of evidence that its activities were impacting upon the higher education sector. Had the Programme's first external evaluators not filed for voluntary insolvency during Easter 2011, this would have undoubtedly helped, however, the longer-term nature of curriculum change means that the true impact of activities are often not evident until delivery with students is underway. For the Programme, this typically did not occur, certainly for activities that required changes to the curriculum, until 2011/12. As such, it is only now post Programme that the extent of the impact of its work is becoming truly evident.

Recommendation 5: Large scale Funding Council projects should consider including a research and evaluation strand with dedicated staffing to assist with evaluation, the capture of learning, and the ongoing measurement of impact and success.

12. The Funding Councils enabled CFE to continue their evaluation of the Programme until December 2012 which proved beneficial. There is, however, a valid case for the evaluations of large-scale projects to continue for a year after they conclude in order to enable the full range of data and evidence to be captured. Equally, there are benefits to projects of embedding an education and research component as part of their activities; this might be through dedicated staff members with expertise in educational research or evaluation, and/or PhD studentships. This would not only allow learning to be analysed and explored, but would support the development and implementation of methodologies to aid the capture of data and evidence, including the identification and internal monitoring of both qualitative and quantitative indicators of success.

Recommendation 6: On distributed Funding Council projects, the project lead within a particular institution should be a permanent member of staff who is either seconded or has a significant proportion of their time allocated to work on the project.

13. Programme staff were critical to taking forward the activities of the Programme, however, despite the best efforts of all involved, key appointments were not made until some months after it had formally started. This further reinforces the need for an appropriate 'start-up' period to allow recruitment to begin prior to a project commencing.

14. In several Programme Partners, key staff were seconded from other roles within their institutions, or had a proportion of their time allocated, to begin work on implementing the Programme before the end of 2009. Having staff engaged in a project from within an institution offers a number of benefits: they are able to begin work on implementation much more quickly; they have knowledge of policies and procedures and access to key institutional contacts, including senior management; they have established relationships with other staff members who they can engage in support of initial activities; and, they will typically remain within the institution after the end date of a project and so are in a position to support the formal aspects of its conclusion. While there are a number of benefits, it is essential for the institutions themselves to ensure such staff are fully supported, as evidenced within the Programme, and have an appropriate proportion of their time allocated to work on the activities of the project.

Recommendation 7: Developed processes and procedures should be shared between Funding Council projects. This would, at the very least, allow a basis upon which new projects could build, but would also allow effective practices to be shared and developed.

15. With a project the size of the National HE STEM Programme, a key feature of early stage activities is the need to develop appropriate policies and procedures, including terms of reference, evaluation frameworks, communication and dissemination strategies, resource allocation models, and monitoring and reporting arrangements. At the same time as recruiting Spokes and staff members, the Hub needed to undertake the development of such documentation as part of good governance procedures. It would therefore be helpful if examples and templates from other funding projects could be made available by the Funding Councils and shared as examples of effective practice. As a minimum this would provide a 'starting point' for their development, but would also allow good practice to be shared.

Recommendation 8: A mentoring scheme should be established for those running Funding Council projects. Such an approach will allow learning and prior experiences to be shared.

16. Furthermore, those involved in undertaking such projects might benefit from an independent mentor; someone who has worked on a similar initiative and as such has advice, expertise and experience that they can share. While the Programme benefited from ongoing support by representatives from the Funding Councils, the advice of a mentor would be different as it would be focused upon the challenges and practicalities of running such externally funded projects.

Recommendation 9: Standard legal and contractual arrangements should be developed for distributed projects, or for projects where further higher education institutions will become involved. These should operate within the overall framework that the Funding Councils have with higher education institutions.

17. One of the areas where the Programme experienced challenges is in establishing legal agreements with both Programme partners and projects. While such agreements are an essential part of good governance when working with public funds, they are notoriously difficult to agree and the Programme experienced challenges in this area. Despite standard agreements being made available to potential projects prior to commissioning, subsequent changes were often requested which became time consuming.

18. For the projects that the Programme commissioned, these were almost universally led by higher education institutions, and as such, at its simplest level HEFCE and HEFCW funding was transferred between HEFCE and HEFCW funded institutions. As universities will already be in receipt of substantial HEFCE and HEFCW funding, a framework could be developed to allow funds to be transferred between higher education institutions without the need for additional contracts and agreements. This must not, however, replace the need for a clear and explicit understanding by both parties of delivery expectations and timescales.

Recommendation 10: The Funding Councils should broker links between their funded projects where there are common interests. This should, however, extend beyond meetings to include the development of formal action plans detailing how the projects will work together; the action plan should be maintained and monitored by the Funding Councils to enable progress to be reviewed.

19. The Programme operated within a landscape in which a range of other organisations were operating with complementary missions and goals. Some of these were HEFCE and HEFCW funded and not all had STEM as their focus; as such, they would not have been a natural part of the

networks in which the Programme operated. While the Funding Councils were able to develop and broker relationships with these organisations and projects, it would be helpful for this to be extended. It is suggested that a formal group be established to bring complementary HEFCE and/or HEFCW projects and organisations together in a model similar to that of the STEM Cohesion Group. This would provide a formal basis for collaboration and shared working to develop between these organisations and projects, whose progress could then be monitored and recorded. At the very least, such an approach would assist with dissemination.

Recommendation 11: A clear statement should be provided at the outset of any project relating to the availability of project outputs and the extent to which materials need to be made freely available. Where appropriate, Creative Commons licenses should be used and a single common location for hosting of outputs from all Funding Councils projects implemented.

20. The Programme sought to make all of the outputs from its work freely available, and Creative Commons[1] licenses were implemented as a means of achieving this but not until the later stages of the Programme. Creative Commons provides a framework for the sharing of resources and materials, and make it clear how others may utilise or build upon these within the future. While many Programme outputs were willingly made freely available, some universities were uncomfortable sharing outputs, in particular teaching and development materials for workforce upskilling citing future business interests. This posed challenges for the Programme and is interesting in the context of the now increasing move to freely available open learning materials and courses by universities as part of national and international initiatives.

21. On reflection clear guidelines should have been provided by the Programme considering all aspects and possible scenarios of making resources freely available across all strands of activity. This could either be addressed by each project individually, to take into account the nature of their individual circumstances, or through the production of a Funding Council policy that applies to all projects and explicitly addresses the issue of learning materials developed to support business engagement.

22. Furthermore, a challenge for any project when it concludes is ensuring that its developed resources are freely, and widely available for others to access. At present there appears to be no one location where such materials from previous projects are collectively located. A single agreed repository, with a Funding Council policy on this, would form a natural starting point for those wishing to build upon activities in the future.

Recommendation 12: A review period, supported by the Funding Councils, should be implemented for all projects post completion to ensure all learning has been captured and appropriately packaged in order that it might form a legacy for the higher education community.

23. A number of the Programme's projects did not conclude their activities, through the production of final reports and case studies, until after the Programme formally ended. In addition, it is known that there are outputs that still remain to be appropriately packaged and made available as some projects committed to continuing their development after the Programme ended. Furthermore, there remains learning from across various strands that require assimilation and analysis.

[1] http://creativecommons.org

24. Work continues to ensure all projects outputs are freely available by Programme Partners, and the University of Birmingham through its STEM Education Centre is collating learning and effective practice from across the strands of Programme activity. The Funding Councils should consider how this process might be supported for future projects, possibly through a review period, although this might, to an extent, be addressed through a ‘stand down’ period.

Section 12:
Case Studies

List of All Case Studies

Case Study	Higher Education Institutions Involved	Case Study Title/Theme
1	16 HEIs	Transfer and Embedding of Chemistry for our Future Activities – Outreach and Widening Participation
2	5 Lead HEIs; over 25 other HEIs involved	Transfer and Embedding of London Engineering Project Activities – Outreach and Widening Participation
3	Derby, East Anglia, Staffordshire, Wolverhampton	Working with STEM Organisations and Initiatives (England) – STEM Clubs
4	Bangor, Glyndŵr	Working with STEM Organisations and Initiatives (Wales) – STEM Clubs
5	6 HEIs	Working with STEM Organisations and Initiatives – Accredited STEM Careers Training
6	19 HEIs	A Community-wide Approach to Public Engagement and Outreach (Mathematics)
7	21 HEIs	A Community-wide Approach to Public Engagement and Outreach (Chemistry)
8	University College London	Institutional Perspectives – Spectroscopy in a Suitcase
9	University College London, Coventry, Durham, Liverpool	Professional Development in STEM - Outreach
10	8 HEIs	Professional Development in STEM – Gender and Diversity
11	Bath (Lead Partner)	Sharing Effective Practice Through Partnership and Collaboration – Evaluation of STEM Outreach
12	RAEng (Lead Partner)	Sharing Effective Practice Through Partnership and Collaboration – Supporting University Technical Colleges
13	Exeter	Building a Community of Practice in Outreach and Widening Participation

Case Study	Higher Education Institutions Involved	Case Study Title/Theme
14	Bath, Bradford, Manchester Metropolitan, Cardiff, Wolverhampton	Collaborating with Civil Society Organisations in Outreach and Widening Participation
15	6 HEIs	Collaborative Regional Approaches to Outreach (North West)
16	Bath, Bristol, West of England, University College London	Collaborative Regional Approaches to Outreach (South West)
17	18 HEIs	Developing Strategic Relationships – Teacher and Industrial Advisory Boards
18	Sunderland, Sheffield	Working Across the School-University Interface
19	Hull, Bradford	Working with Primary Schools
20	Queen Mary London	Institutional Perspectives – Public Engagement
21	West of England, Plymouth	Institutional Perspectives – Coherent STEM Strategies
22	Aberystwyth	Institutional Perspectives - Transfer and Embedding of Outreach Activities I
23	Bangor	Institutional Perspectives - Transfer and Embedding of Outreach Activities II
24	Chester	Institutional Perspectives – Strategic Approaches to Regional Working
25	York	Widening Participation Through Lifelong Learning
26	IMA (Lead Partner)	Creating and Disseminating Resources for use by those in the Pre-University Sector
27	Bradford	Support at the Transition – trans:it
28	**sigma** (Lead Partner)	Mathematics Support at the Transition to University Study
29	**sigma** (Lead Partner)	A Community-wide Approach to Mathematics Support – The **sigma** Network
30	York, Warwick	Institutional Perspectives - Mathematics Support
31	9 HEIs	Transfer and Embedding of Stimulating Physics Project Activities – Problem Based Learning
32	Salford	Transfer and Embedding of Stimulating Physics Project Activities – Repackaging Physics
33	26 HEIs	Transfer and Embedding of Chemistry for our Future Project Activities – Context and Problem Based Learning
34	8 HEIs	Developing Problem, Context and Puzzle Based Learning Within the Mathematical Sciences
35	Plymouth, Bristol	Meeting a Need – Real World Industrial Problems for Undergraduate Mathematical Sciences Courses
36	20 HEIs	A Physics Community-wide Approach – Industrial Group Projects
37	Bath	Institutional Perspectives – Industrial Group Projects
38	8 HEIs	Student Engagement in STEM
39	Loughborough, Exeter	Institutional Perspectives – The Practice Transfer Adoption Scheme

Case Study	Higher Education Institutions Involved	Case Study Title/Theme
40	Birmingham, Leicester, Nottingham Trent	Curriculum Change within the Mathematical Sciences
41	23 HEIs	A Community-wide Approach to Assessment
42	18 HEIs	Sharing Effective Practice to Stimulate New Developments in Employability
43	8 HEIs	Sharing Effective Practice to Stimulate New Developments in Student Engagement – The Maths Arcade
44	Imperial College (Lead)	Sharing Effective Practice Through Partnership and Collaboration – STEM Labs
45	Southampton, Plymouth, Bath, London School of Economics	Supporting Student Access to STEM
46	Portsmouth	Institutional Perspectives – Applied Physics
47	Durham	Institutional Perspectives - Enhancing Laboratory Provision
48	Southampton, Reading, Queen Mary, Salford, Bradford	Institutional Perspectives – Recording Lectures
49	Liverpool John Moores	Understanding Graduate Career Progression and Motivation
50	Northumbria University	Interactive Technologies to Support Employability
51	Lincoln	Institutional Perspectives – Engaging Employers in Curriculum Design and Delivery
52	Imperial College	Engaging Employers in Curriculum Design and Delivery – The Nuclear Island
53	Birmingham, Nottingham Trent, Aston	Engaging Employers in Curriculum Design and Delivery – The Grand Challenge
54	Bradford, Leeds Metropolitan, York	Embedding Sustainable Change and Greening STEM
55	Birmingham, Queen Mary, Bradford	Building Graduate Skills Through Science Communication
56	Plymouth	Meeting Employer Workforce Needs Through Distance Learning – The Hydrographic Academy
57	8 HEIs and FECs	Collaborative Approaches for Workforce Learning – Photonics Upskilling
58	12 HEIs	A Regional Approach to Increasing University and Employer Engagement - STEMBUG
59	7 HEIs and FECs	A Regional Approach to Meeting Employer Needs Through Professional Development Opportunities
60	10 HEIs	Developing New Provision Through Partnership and Collaboration – Engineering Gateways
61	Hull	Institutional Perspectives – Creating Part Time Learning Opportunities in STEM
62	Swansea Metropolitan	Meeting Employer Workforce Needs – Fast-track and Escalator Provision
63	Wolverhampton	Meeting Employer Workforce Needs – Gearing up for Industrial Growth

Case Study 1: Transfer and Embedding of Chemistry for our Future Activities - Outreach and Widening Participation

Activity:	Chemistry Outreach Package and Chemistry at Work
Institution(s):	Bangor University, University of Bath, University of Bradford, University of Cambridge, University of Exeter, University of Leeds, University of Leicester, Liverpool John Moores, University of Manchester, Northumbria University, University of Oxford, University of Reading, University of Sheffield, University of Southampton, Swansea University, University of York
Activity Description:	Within Chemistry for our Future a series of 16, different scale, fully evaluated outreach activities aimed at students from 5 – 18 years of age were developed; through an open call, higher education institutions were asked to implement at least three of these activities using full instructions and guidance materials. Chemistry at Work enabled higher education institutions to implement a one or two-day event consisting of careers presentations and demonstrations to benefit students from 11-16 years of age by providing the opportunity for them to appreciate the place of chemistry in everyday life and the world of work.
Outcomes:	• A minimum of 4900 students (excluding those at science fairs) from over 190 schools and colleges participating in the activities offered. • 104 teachers participated, including new or trainee teachers who developed and contributed to outreach activities as part of their programmes of study. • Specific approaches to targeting underrepresented groups of learners adopted and embedded by departments, including collaborative approaches with existing STEM organisations and initiatives[1], and cross-institutional approaches. • Alignment made with the Spectroscopy in a Suitcase initiative. • Extension of the range of outreach provision offered to include provision offered to younger age groups, and increased involvement of postgraduate and undergraduate students to aid their skills development. • The University of York has adapted the Chemistry at Work day to Physics meaning there are now '…at Work' activities for Chemistry, Mathematics and Physics.
Legacy:	**"In response to the high demand for places on the Year 9 Chemistry Day course the team are developing the project so that it can additionally be run in schools as part of the Spectroscopy in a Suitcase initiative."** [Academic Member of Staff, Bangor University] **"One useful outcome for me has been the adoption of "Synthesis and Characterisation of Aspirin", based on these workshops, as a first year university practical."** [Academic Member of Staff, Swansea University] **"From this October, we plan to begin training more undergraduates to deliver outreach and to begin training postgraduates earlier in the year before they have time to make commitments elsewhere."** [Academic Member of Staff, University of Bath] **"We will once again use a significant number of undergraduate students as demonstrators to work with groups of students…"** [Academic Member of Staff, University of Exeter] **"Transfer of best practice is ongoing, through the recently formed University of Leicester College of Science & Engineering Widening Participation and Outreach Working Group."** [Academic Member of Staff, University of Leicester] **"Staff now have more confidence in interacting with younger pupils."** [Academic Member of Staff, University of Reading]

[1] See for example: http://www.ljmu.ac.uk/NewsUpdate/index_120535.htm

Case Study 2: Transfer and Embedding of London Engineering Project Activities - Outreach and Widening Participation

Activity:	Welsh HE-Centred Engineering Outreach; Professor Fluffy Explores Engineering; Disseminating Student Ambassador Top-up Training in Engineering'; Using Student Ambassadors an HEIs to Support Local Secondary Science and Engineering Clubs; Building the Capacity of Engineering Lecturers to Take Part in Outreach
Institution(s):	Swansea University, University of Liverpool, University of Bradford, University of Southampton, University of Wolverhampton
Activity Description:	To transfer the outcomes and learning from the London Engineering Project the Royal Academy of Engineering established, in Year 1 of the Programme, and in conjunction with the Spoke HEIs, 5 large-scale collaborative regional outreach projects. The developed projects focused upon: outreach activities to widen participation and aid progression with a particular focus upon girls and young women in partnership with the Engineering Education Scheme Wales (Swansea); the establishment of a North West Primary Engineering Network to enable the rollout of the Professor Fluffy module within local primary schools (Liverpool); embedding good practice in the use of undergraduate students as ambassadors for STEM through training and staff development to enable future delivery (Bradford); working with teachers to establish science and engineering clubs within their schools with delivery supported by university student ambassadors (Southampton); and, supporting engineering lecturers to engage with, or lead, outreach activities (Birmingham).
Outcomes:	• 32 academic members of staff from 6 HEIs participating in 5 training sessions; 19 academic staff participated in two gender equality workshops facilitated by the UKRC; Approximately 500 primary students (33% female) participated in the Primary Bloodhound Challenge at 3 HEIs; Over 350 girls and young women (23% from Years 12 &13) participated in the Attracting Girls into Engineering Visits; through linking schools with HEIs, 438 Year 12 & 13 students attended induction days in universities or FE colleges across Wales; 90 students participated in a Headstart Cymru residential at two Welsh HEIs supported by undergraduates from 4 universities. • The Network of 8 HEIs in the North West reached 15 primary schools and engaged 401 Year 5 & 6 students with 50% of the participants from BME backgrounds and 50% were female. • In the North-East 460 students and 31 members of staff from 9 HEIs participated in the training sessions. The training has been embedded alongside existing institutional provision: for example at Durham University the training has been integrated into the Science Communication module offered to all level 6 students studying science degrees. • In London and the South East 29 STEM Clubs were supported by 6 HEIs. • 29 academic members of staff and postgraduate students attended the Midlands outreach training events from 6 HEIs.
Legacy:	**"…there will be further development with HEIs and existing partnerships will be sustained and extended through continued involvement with other activities."** [National Director, Engineering Education Scheme Wales] **"Our student advocate team also welcomed the opportunity to work with younger aged pupils, something which they don't usually get experience of. We have since been able to build on these links with the primary schools involved…"**[Corporate Services Member of Staff, Liverpool John Moores University] **"We will definitely use elements of the session in our future training for *all* ambassadors."** [Corporate Services Member of Staff, University of Sunderland] **"The STEM initiative was a major driver for us to create a group of committed and passionate STEM reps who we now use on a regular basis."** [Corporate Services Member of Staff, Northumbria University] **"The model has been incorporated within a programme called 'Learn with Us'[2]. This is a programme that aims to stretch and challenge students who are currently in further education and encourage them to consider university."** [Academic Member of Staff, University of Southampton]

[2] http://www.learnwithus.southampton.ac.uk

Case Study 3: Working with STEM Organisations and Initiatives (England) – STEM Clubs

Activity:	STEM Clubs
Institution(s):	University of Derby, University of East Anglia, Staffordshire University, University of Wolverhampton
Activity Description:	STEM Clubs is a national programme co-ordinated by STEMNET. Clubs exist for Key Stage 3/4 students with the aim of encouraging pupils to continue their STEM education post-16 and to help young people from an early age start to develop employability skills such as report writing, team working and communication. Through this project clusters of STEM clubs were enabled to work with higher education institutions in a new approach.
Outcomes:	• Over 40 STEM Clubs established within schools and colleges across the Midlands and East Anglia region. • A 2011 pilot with a single school was expanded and in 2012 received 17 posters from 6 schools involving 29 Year 8 students [University of Wolverhampton]. • Over 30 students and 7 teachers provided positive feedback after participating in the University of Staffordshire activities. • 12 University of Staffordshire students registered as STEMNET Ambassadors at the start of the project and a further 27 registered in March 2012. 5 of the 6 Ambassadors who provided feedback indicated they wish to participate again next year. • 50 'at risk' Year 9 pupils from 12 schools in East Anglia participated in an energy based enterprise challenge leading to the achievement of a British Science Association Bronze CREST award[3].
Legacy:	**"Sustainability of the project will be achieved through integrating the competition with the popular annual STEM Quiz and the National Science and Engineering week, both in timing and theme."** [Corporate Services Member of Staff, University of Wolverhampton] **"The University has committed to continue this project and provide funding for this activity in 2012/13. Five of the schools involved in this partnership are continuing with one additional local school to be invited to the cluster."** [Academic Member of Staff, Staffordshire University]

[3] http://www.opito.com/uk/about-us/news/490-pupils-explore-energy-industry-in-interactive-enterprise-challenge.html

Case Study 4: Working with STEM Organisations and Initiatives (Wales) – STEM Clubs

Activity:	Discover! Science Saturday Clubs for Girls
Institution(s):	Bangor University and Glyndŵr University
Activity Description:	In 2006 the Discover! Club was established by Cardiff University and Careers Wales Cardiff and Vale exclusively for girls in Year 9 from widening participation backgrounds and aimed to encourage them to select more STEM based subjects at GCSE. Building on the work of Careers Wales Cardiff and Vale, two new Discover! Clubs for Girls were set up in North Wales offering a series of 'hands-on' science workshops on Saturday mornings to offer an insight into careers relating to science, technology, construction and engineering; these activities were supplemented with visits to local STEM employers.
Outcomes:	• At Glyndŵr the club ran in 2011 for 6 weeks, and involved 24 students from 8 schools across north east Wales. Students were given the opportunity to earn a British Association Bronze CREST award for the sessions on sustainable energy. • At Bangor the pilot programme in 2011 initially involved 12 pupils. • Discover! Clubs have now been rolled out across all six Careers Wales regions by extending coverage to HEIs in North Wales.
Legacy:	At Bangor University, the Discover Science Saturday Club for Girls ran again in February/March 2012; 25 girls from 10 schools participated in the activities[4]. It is planned to run again in 2013[5].

[4] http://www.bangor.ac.uk/news/full.php.en?text=false&nid=7354&tnid=7354

[5] http://www.bangor.ac.uk/bangorsciencefestival/full-event.php.en?text=true&nid=11827&tnid=11827

Case Study 5: Working with STEM Organisations and Initiatives – Accredited STEM Careers Training

Activity:	Accredited STEM Careers Module
Institution(s):	Cardiff University, Sheffield Hallam University, Swansea University, University of Warwick, UHOVI (Universities Heads of the Valleys Institute), University of Glamorgan, Wales Institute of Mathematical and Computational Sciences and Babcock International
Activity Description:	In response to concerns regarding the depth of knowledge of career possibilities open to STEM graduates on the part of those currently engaged in careers advice and guidance within the pre-University sector, and in response to significant changes to national changes in careers information, education, advice and guidance across England and Wales, a pilot taught level 7 ten credit equivalent module on offering STEM careers advice was developed in conjunction with the National STEM Centre. The course was largely delivered by distance learning, backed up by two face to face sessions at Cardiff University, funded by the Welsh Spoke. Assessment was based on a project portfolio.
Outcomes:	• Building upon an existing online module[6] a postgraduate-level study module developed including an assessment framework for the portfolio. • 24 participants (12 from Wales and 12 from South-West England) participated in the pilot delivery phase and were supported by their employers; 18 completed all aspects of the assessment. • A very positive evaluation based on interviews with all involved, including students.
Legacy:	**"An overwhelming majority of students, ninety-two per cent, felt that the Careers Module had improved their capacity to provide expert advice on STEM careers."** [External Evaluator, Cardiff University] **"Course tutors reported evidence of culture change among participants at the level of institution, reported in students portfolios' and 'evidence of practice change in the schools'."** [External Evaluator, Cardiff University] The pilot careers module has been validated by the University of Glamorgan as part of its post-graduate programme in careers guidance and is available as a bite-size option module of 10 credits, offered through the University of the Heads of the Valleys Initiative (UHOVI)[7].

[6] http://www2.warwick.ac.uk/fac/soc/ier/ngrf/stem

[7] http://www.uhovi.ac.uk/course/postgraduate-certificate-in-career-guidance.aspx

Case Study 6: A Community-wide Approach to Public Engagement and Outreach (Mathematics)

Activity:	Mathematics Large OutreaCh Kits (MLOCK)
Institution(s):	Aberystwyth University, University of Bolton, Brunel University, University of Chester, Coventry University, Durham University, University of Greenwich, University of Hertfordshire, University of Central Lancashire, University of Lancaster, University of Leeds, Liverpool John Moores, University of Manchester, Manchester Metropolitan University, University of Plymouth, University of Portsmouth, University of Salford, University of Sheffield, Swansea University.
Activity Description:	During the course of the Programme a lack of high quality interactive 'hands on' activities were identified as a barrier to university mathematics departments engaging with careers fairs, science fairs, and open days. To address this a series of large interactive activities were developed that form the Mathematics Large OutreaCh Kits (MLOCK) in a manner similar to that of the Royal Society of Chemistry's Spectroscopy in a Suitcase initiative [Case Study 6].
Outcomes:	• Each MLOCK kit consists of seven large outreach items developed by bringing together effective practice from across the mathematical sciences sector. • Collaborations have been established between regional HEIs to enable the sharing of the kits. • Utilisation of the MLOCK kits at regional and institutional events by HEIs, and an increased engagement by the mathematical sciences community with the 2011 and 2012 Big Bang Fairs.
Legacy:	**"The kits contain form really interesting objects which inspire you to go out and motivate young would-be mathematicians. It makes a major contribution to mathematical outreach."** [Head of Department, Sheffield Hallam University] 19 MLOCK kits distributed across England and Wales. A (free of charge) loaning system between HEIs ensures every mathematics department has available access to an MLOCK kit[8] for use in outreach activities.

[8] See, for example: http://www.maths.leeds.ac.uk/index.php?id=342

Case Study 7: A Community-wide Approach to Public Engagement and Outreach (Chemistry)

Activity:	Spectroscopy in a Suitcase
Institution(s):	Anglia Ruskin University, Bangor University, Cardiff University, Durham University, Imperial College London, Northumbria University, University College London, University of Bath, University of Bradford, University of East Anglia, University of Leicester, University of Liverpool, Liverpool John Moores, University of Manchester, University of Plymouth, University of Reading, University of Sheffield, University of Southampton, and University of Surrey
Activity Description:	Portable spectroscopic equipment is taken into schools by trained undergraduates, postgraduates and academic staff to deliver activities that teach students about spectroscopy through context-based learning. The equipment is also available for schools to use as appropriate, either for workshops, supporting extended projects or after school science clubs.
Outcomes:	• 19 Higher Education Institutions who host the equipment and 17 kits located throughout the UK. • Over 26,000 students engaged in activities since August 2009 at over 520 events. • Development of the SpectraSchool website[9] providing supporting resources and materials and the implementation of an online booking facility for schools[10]. • Collaborative approaches to delivering spectroscopy in a suitcase activities have been adopted by higher education institutions: for example the University of Liverpool and Liverpool John Moores University.
Legacy:	• Continued support for the Spectroscopy in a Suitcase initiative will be provided by the Royal Society of Chemistry until at least the end of July 2014. • The participating higher education institutions have embedded Spectroscopy in a Suitcase as part of their outreach activities[11]. • Implementation of a similar national scheme within the mathematical sciences (MLOCK) (see Case Study 6), through the 'Luggage Lab' project in physics at the University of Hertfordshire, and Science Van/Gwyddfan at Aberystwyth University [Case Study 22].

[9] http://www.le.ac.uk/spectraschool/

[10] http://www.rsc.org/Education/sias/siasbooking.asp

[11] See for example: http://www.chem.leeds.ac.uk/home/schools-outreach/chemistry-workshops.html or http://www.bath.ac.uk/chemistry/extracurricular/

Case Study 8: Institutional Perspectives - Spectroscopy in a Suitcase

Activity:	Spectroscopy in a Suitcase
Institution(s):	University College London
Participating Department(s)	Department of Chemistry
Activity Description:	Portable spectroscopic equipment is taken into schools by trained undergraduates, postgraduates and academic staff to deliver activities that teach students about spectroscopy through context-based learning. The equipment is also available for schools to use as appropriate, either for workshops, supporting extended projects or after school science clubs.
Outcomes:	• During the school year 2011/12, workshops were delivered to 8 schools (reaching 225 students); teacher inset training delivered at 3 school consortia to 35 teachers; equipment loaned to 10 schools with the delivered workshops reaching around 1100 students. • Schools continue to request the provision of teacher training days, not only in the use of the equipment, but also for those teachers (non chemistry graduates) to whom the material is unfamiliar. • Over 80 applications (approximately 10%) of students to UCL Chemistry mentioned a spectroscopy workshop at their school in personal statements last year; similar statistics are evident this year (2012/13). • 5 schools without prior student applications to study Chemistry at UCL in the last five years but who have participated in the scheme in the past 12 months have applications thus far this year.
Legacy:	The Spectroscopy in a Suitcase initiative is embedded within the outreach provision offered by the Department and as such it continues to be made available to schools and colleges[12].

[12] http://www.ucl.ac.uk/chemistry/outreach/schools

Case Study 9: Professional Development in STEM – Outreach

Activity:	Outreach Workshop: Doing Outreach and Extending Your Outreach
Institution(s):	University of Central London, Coventry University, Durham University, University of Liverpool
Activity Description:	Through an open call, higher education institutions were offered the opportunity to host one of two self-contained workshops aimed at university staff who were interested in improving their own public outreach activities and confidence, and gaining skills related to applying for funding and undertaking evaluation. **Doing Outreach** was a one-day introductory workshop for HEI staff who are interested in getting involved with public engagement and outreach activities and **Extending Your Outreach** was a one-day workshop for HEI staff who have some prior experience of taking part in public engagement outreach activities. Both activities were originally developed through the Stimulating Physics Project.
Outcomes:	• A minimum of 44 academic members of staff and postgraduate students participated in the four training sessions. • New cross School collaborations were established at the University of Liverpool as a result of the workshop which led to the joint development and delivery of outreach activities and the sharing of effective practice. • The 20 Year 1 and Year 2 chemistry postgraduate students who participated at UCL received training points for attending and delivering outreach activities. • The workshops developed at UCL for National Science and Engineering week were developed with a 'user manual' thereby enabling others to run the activities in the future.
Legacy:	**"Since the event all staff have been more enthusiastic about presenting and encouraging their postgrads and postdocs to become involved with on campus events and consider the Researchers in Residence programme as an option. Further running this event has led to collaborations which will have interdisciplinary events running in schools..."** [Academic Member of Staff, University of Liverpool] **"Many events coordinated by the students who attended this training event are now in the early or late planning stages. These include several events for National Science and Engineering Week… students who attended this training event are also running Junior Masterclasses for year 9 students over the next few months, with 5 events currently planned and more anticipated."** [Academic Member of Staff, University of Central London]

Case Study 10: Professional Development in STEM – Gender and Diversity

Activity:	Gender & Diversity Workshop, and Gender Equality in STEM - Training for Careers Professionals
Institution(s):	Coventry University, University of Birmingham, University of Liverpool, University of Wales Newport, University of Northampton, Oxford Brookes University, Sheffield Hallam University, Southampton Solent University
Activity Description:	Through the London Engineering Project, two one-day training workshops were developed and these workshops, delivered by the UKRC, were offered to Higher Education Institutions through an open call. The Gender Awareness training was designed to enable university departments to better understand the issues affecting women and girls within STEM and the positive actions that can be taken to address them, and the Gender & Diversity Workshop explored gender awareness issues in delivering outreach, and provided an opportunity to develop familiarisation with diversity guidelines and use of the DRIVE process developed during the London Engineering Project. From February to June 2012 the UKRC delivered five further workshops across England on gender equality in STEM for careers professionals working with adults and in higher and further education.
Outcomes:	• A minimum of 37 academic members of staff and postgraduate students participated in the four training sessions derived from the pilot projects. • The development and delivery of a series of Women in Physics events at the University of Liverpool which continue to be offered to schools and colleges[13], and a range of collaborative activities at Southampton Solent University. • An increased awareness within the institutions of the problems and challenges faced by female students. • 70 participants attended the 5 events held between February and June 2012. • In May 2012 Coventry University became a member of the Athena Swann Charter initiated by the Project Lead; the University of Northampton also joined in January 2012[14].
Legacy:	**"Since the event the Department has run a Women in Physics event for AS-level students (July 2011), and its success has led to the development of Young Women in Physics (Feb 2012), WiP 2012 (June 2012) and involvement in all-girls science events in schools."** [Academic Member of Staff, University of Liverpool] **"The heightening of awareness and ability to discuss action plans showed some real progress."** [Academic Member of Staff, Coventry University] **"Since the training, we have seen an increased number of activities in the Maritime and Technology faculty as well our Sports Science faculty. The main aim has been to encourage the academic staff to take ownership and deliver a combination of aspiration and curriculum led activities in partnership with Solent Partnerships team to school pupils and prospective college students with an increased participation of female students."** [Corporate Services Member of Staff, Southampton Solent University] **"We have run a girls only STEM event held here at the university where 8 of our local secondary schools brought along a group of girls to experience taster sessions of SET courses and speak to some of our female students and academics."** [Workshop Participant (follow-up survey response)]

[13] http://www.liverpoolphysicsoutreach.co.uk/#/women-in-physics/4567674256

[14] http://www.athenaswan.org.uk/members_list

Case Study 11: Sharing Effective Practice Through Partnership and Collaboration – Evaluation of STEM Outreach

Activity:	Effective Evaluation of STEM Outreach Practice Transfer Partnership
Institution(s):	University of Bath, National Coordinating Centre for Public Engagement, Beacons for Public Engagement
Activity Description:	An initial survey (161 responses) undertaken through the Programme identified significant interest across the HE STEM sector in training to support the evaluation of outreach and public engagement activity: the survey highlighted high quality online materials and workshops were the preferred method for individuals to access this support. Through this activity a package of support for the evaluation of STEM outreach and public engagement was developed.
Outcomes:	• 3 training courses developed: 'The Beginner's Guide to Evaluation', the 'Evaluation Masterclass' and three 'Plug and Play' sessions for integration into other meetings. • Development of a 'Train the Trainer' course to support trainers running 'The Beginner's Guide to Evaluation' for themselves. • 12 national sessions offered attracting 145 participants.
Legacy:	• Evaluation of the events indicated participants had gained new ideas and increased confidence to evaluate activities. • High-quality materials for evaluating outreach and public engagement freely accessible to the sector[15]. • Training events will continue to be offered, and events have already run during 2012/13. Plug and Play modules will be integrated within appropriate events.

[15] http://www.publicengagement.ac.uk/evaluating-stem-outreach

Case Study 12: Sharing Effective Practice Through Partnership and Collaboration – Supporting University Technical Colleges

Activity:	Supporting the Development of University Technical Colleges (UTCs) Practice Transfer Partnership
Institution(s):	The Royal Academy of Engineering (lead), The Baker Dearing Trust, The Black Country UTC, The JCB Academy, Bristol Academy of Technology and Engineering (+40 aspiring UTCs, their partner higher education institutions and employers)
Activity Description:	University Technical Colleges are an example of a much wider phenomenon: higher education institutions being involved in the development and delivery of provision for 14-19 year old learners. At the time of the project, only two UTCs (JCB Academy and Black Country) were operating, yet there was a great deal of activity underway within the higher educations sector to develop UTC provision, and a real risk each would approach the development of provision in its own way, with the result of large-scale duplication and the fragmentation of expertise; conversely, there was also a significant body of knowledge on effective partnerships and approaches for delivering STEM 14-19 curricula. Through the Practice Transfer Partnership, a series of national workshops and seminars were held help to bring together the current and future UTC community to develop collaborations and share effective practice.
Outcomes:	• Establishment of a community of practice including all Principals, teachers, employers, and higher education institutions associated with UTCs (some 40+ UTC consortia). • Significant work undertaken on the development of the UTC curriculum has established a solid foundation for the UTC community[16]; in particular dialogue has been opened with qualifications awarding bodies. • A mechanism has been developed for engaging undergraduates in universities associated with UTCs as mentors, curriculum designers, teachers and demonstrators.
Legacy:	**"It proved to be important to be responsive to the rapidly changing needs of UTCs as during the period of the project the government recognition of the technical STEM qualifications offered by UTCs (such as the 14-19 Principal Learning qualification in Engineering) changed."** [Royal Academy of Engineering Representative] **"The seminar I attended brought all the relevant people into one room. In a few hours I was brought up to date on curriculum options and qualifications that I could use in the UTC to be opened in a few months' time. I could make critical, informed decisions."** [Principal designate of an aspiring UTC] • Three further follow-on seminars were held building upon the earlier events and focusing upon alignment of the curriculum with professional engineering standards and delivery mechanisms. • From a small initial base (2 open UTCs) a larger community of practice has emerged which will be sustained through the Royal Academy of Engineering.

[16] http://www.utcolleges.org.uk/media/56815/respected_hires%2029.9.11.pdf

Case Study 13: Building a Community of Practice in Outreach and Widening Participation

Activity:	Creating a Community of Practice for Outreach and WP Practitioners
Institution(s):	University of Exeter
Activity Description:	This project[17] developed a South West Community of Practice for STEM outreach and widening participation (WP) practitioners, encouraging online and face-to-face dialogue between local experts across universities in the South West and beyond. As well as organising regional seminars and discussions to share good practice, cross-institutional coordination was facilitated. Constructive peer reviews enabled practitioners to constructively evaluate each other's activities through visiting each other's outreach events.
Outcomes:	• An online community of practice hosted on the Open University's Lab Space[18]. • A JISCMail group created to foster discussion amongst WP and outreach practitioners[19]. • Peer review and shadowing facilitated between practitioners in the South West. • Two regional events, which saw over 70 STEM outreach practitioners from across the university, FE college and third sectors coming together to share best practice and to learn from leaders in the field and other practitioners. • Case study of the outreach and widening participation activities at the University of Exeter. • Comparative report of access agreements across six South West universities that identifies outreach and WP activities, together with plans for evaluation and monitoring of these activities across the institutions. • Research papers produced, outlining issues such as the benefits and challenges of establishing communities of practice and access agreements across south west universities. • Creative Learning Journeys[20] - a mixed media digital portfolio capturing progress of the project through audio, photography and video means. • Adoption of the community of practice project at three other universities (Bradford, Hertfordshire and Loughborough), resulting in 16 new and improved STEM outreach activities, and strengthened links between these universities and local community organisations.
Legacy:	Continuation of the online Community of Practice, via the project website hosted by the Open University, along with the JISCMail discussion group established by the project. The success of this project led to the formation of a national project that created multiple communities of practice across the country aimed at strengthening links between voluntary and community sector (third sector) organisations and universities in the field of STEM outreach[21] (see Case Study 14) The three adopter universities through the Practice Transfer Adopter process have all established new partnerships and outreach activities that will continue into the future.

[17] http://www.hestem-sw.org.uk/project?id=10

[18] http://labspace.open.ac.uk/course/view.php?id=6767

[19] https://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=STEM-OUTREACH-SW

[20] http://www.creativestem.co.uk/

[21] http://www.hestem-sw.org.uk/national-community-of-practice/collaborating-with-the-third-sec/

Case Study 14: Collaborating with Civil Society Organisations in Outreach and Widening Participation

Activity:	Collaborating with Civil Society Organisations in STEM Outreach
Institution(s):	University of Bath, Access HE, University of Bradford, Manchester Metropolitan University, Cardiff University, University of Wolverhampton
Activity Description:	Building upon the success of its regional project on **Developing a Community of Practice for Outreach and WP Practitioners** (see Case Study 13), the South West Spoke initiated a national project[22], managed by Access HE, aimed at fostering collaboration between universities and civil society organisations (CSOs) i.e. voluntary and community sector organisations in the field of STEM widening participation, through a community of practice model. The intended benefits for the HE sector were improved approaches to targeting and supporting under-represented groups; these would derive from universities learning from CSOs with extensive experience of working with disadvantaged communities, together with access to the networks that these organisations bring. The intended benefits for the CSO partners were an enhanced appreciation of the specific opportunities and challenges related to STEM Widening Participation activities and STEM study at HE level, as well as closer ties with universities nationally. The project facilitated closer working between universities and CSOs to share and further develop activities that have demonstrated proven impact in supporting, and raising the aspirations of, children and young people from disadvantaged backgrounds to HE STEM study.
Outcomes:	• Formation of a strategic, distinctive national community of practice between HEIs and civil society organisations (including IntoUniversity, Helena Kennedy Foundation, Talent 2030, Teach First, Villiers Park Educational Trust, Science Learning Centre SW, STEMNET and AccessHE, National Coordinating Centre for Public Engagement, @Bristol, Space Connections and Generating Genius). • Formation of a national forum to support the development of an agenda for the national community of practice through engaging strategically relevant organisations. • Five exemplar projects undertaken, with CSOs (Villiers Park, Teach First, Space Connections, Generating Genius and @Bristol) leading on developing models of collaborative STEM outreach in partnership with HEIs. • Creation of a website[23] to bring together good practice developed within the project alongside: evidence of other HEI-CSO collaborations and resources to support collaborative outreach. • Formation of five regional communities, centred around HEIs in the National HE STEM Programme spoke regions, to enhance local and regional collaborations between universities and CSOs in the field of STEM outreach. • A report on CSO-HEI collaborations, entitled **Unblocking the pipeline: How the third sector can increase HE participation in STEM subjects**. • A national conference in London, attended by around 100 delegates from a wide variety of organisations.

Legacy:	• Building upon the success of this project, the University of Bath and Access HE launched the Centre for HE STEM Access and Civil Society in October 2012. The Centre aims to: • Promote collaborations between HEIs and CSOs in delivering activities to enable progression to HE from currently under-represented groups; • Further extend the activities and influence of the national and regional communities of practice that were formed through this project; • Establish the nature of the added value provided by HEI-CSO collaborations to HE STEM access and to engage with policymakers. • The Centre's activities during 2012-13 will include: • Further developing the website bringing together additional resources and examples of best practice in the delivery of such activity, as well as connecting interested individuals; • Continuation of the National Forum to establish the strategic agenda and inform the activities of the Centre; • A seminar programme to enable those working on HE STEM progression to link with each other and other key stakeholders, in particular funders and policymakers; • Continue to develop the five regional communities of practice, supporting them to: • bring together STEM academics and outreach workers from regional HEIs alongside representatives from CSO that are experienced, or interested, in STEM outreach, to identify and tackle regional or local challenges in STEM outreach; • encourage the sharing of mutually beneficial good practice and resources across sectors.

[22] http://www.hestem-sw.org.uk/national-community-of-practice/collaborating-with-the-third-sec/ and http://www.hestem-thirdsector.org.uk/.

[23] www.hestem-thirdsector.org.uk

Case Study 15: Collaborative Regional Approaches to Outreach (North West)

Activity:	Children Challenging Industry – Enriching the STEM Curriculum at Key Stages 2 & 3
Institution(s):	Manchester Metropolitan University, University of Manchester, University of Liverpool, Liverpool John Moores University, University of Bolton, University of Chester
Activity Description:	The 'Children Challenging Industry' project led by the Chemical Industry Education Centre at the University of York trained HEI staff and postgraduates and secondary school teachers to develop awareness of STEM based careers and deliver innovative applications of science for younger people from Widening Participation backgrounds at the Key Stage 2 - 3 transition. It addressed two key problems: negative perceptions held by younger people of science and a lack of awareness of careers in STEM industries.
Outcomes:	• Increased interaction between North West higher education institutions and local secondary schools, working with their primary feeder schools, to proliferate widening participation in STEM related subjects. Six HEIs, 10 secondary schools and 40 of their associated primary schools have been linked to develop networks and establish effective practice for supporting science teaching. • In excess of 50 primary teachers have been given opportunities to try practical activities and provided with resources to carry out science practical sessions with classes of upper Key Stage 2 children. • 30 HEI ambassadors recruited and trained consisting of postgraduate students, academic members of staff, and undergraduates. Ambassadors have been linked with the STEMNET scheme. • A sustainable network of at least 20 HEI ambassadors from 5 HEIs has been established. • Training provided by the project team was universally valued, with 99% of participants rating the input as either excellent or good. Training resources available to sector to support future sector-led training of postgraduates to deliver outreach activities.
Legacy:	**"There are a number of positive legacies from this engagement that the University is committed to embed and sustain in the future. In particular the Programme has enabled; closer working with HEIs in the region (such as The University of Manchester and Liverpool John Moores), enhanced Outreach offerings through investment in demonstrator equipment (e.g. Large-scale Maths Outreach and Conference Kits), and more strategic targeting of WP groups through comprehensive mapping of provision across the region."** [Extract from Manchester Metropolitan 2012 OFFA Agreement] **"We will offer termly KS2/3 liaison meetings, which we have run very successfully in the past. They run after school and the agenda is shared to meet the needs of the schools. They go away with practical resources too, including literacy. The schools are welcome to book our labs and schools have taken advantage of this facility. Our Primary school liaison scheme runs weekly and schools visit to use the labs or staff will go out to their site."** [Assistant Head, Bankfield School, Widnes]

Case Study 16: Collaborative Regional Approaches to Outreach (South West)

Activity:	Developing & Enhancing STEM Communicator Models
Institution(s):	University of Bath, University of Bristol, University of the West of England, University College London, Institute of Physics, Science Learning Centre South West
Activity Description:	This project involved the sharing of good practice in STEM communications between academics and students at all partner organisations and facilitated the direct comparison of three different types of STEM communication models - paid, volunteer and accredited models[24].
Outcomes:	• Extended, existing good practice, exposing students to richer training opportunities and facilitating their participation in a variety of STEM activities, including Science Fairs and Royal Institution Masterclasses. • Longitudinal research evaluating the experiences of 60 STEM student communicators in order to better inform how to embed and improve STEM communication activities influencing the embedding of new accredited modules in STEM communications across the universities of Bath and Bristol. • **A Guide to Student Involvement in STEM Activities,** for those considering STEM communication activities for the first time illustrating the different models and providing top tips and links to a range of advice and resources. • Inclusion of the University of Bath's Maths Communicators module in the Vorderman report to government on the teaching of mathematics in England and its successful bid to the RCUK to become a Public Engagement with Research Catalyst. • Recognition of the impact of student communicators at science fairs and at mathematics masterclasses by the British Science Association and the Royal Institution.
Legacy:	**"Communicating Science was a very welcome opportunity to become involved in outreach through the University. It was refreshing in that it was a unit with no lectures, but instead tutorials, which were more intimate and allowed for discussion. Connecting with younger students and the public, I feel, was an enriching experience that allowed us to venture out of the 'student bubble'".** **"When you're a student and you're doing your degree, you've got to be constantly thinking in the back of your mind about your CV. And just in everything it shows you're willing to get stuck in. Obviously, it's a confidence builder, you improve your presentation skills, the way you put yourself forward, your ability to work in a team; it shows a lot of competencies that employers are looking for".** [Student quotes] **"It was really useful to identify the employability skills that students develop from outreach activities and to understand better the motivations of students to do outreach work".** **"I aimed to get a more rounded understanding of university STEM WP activities and how students are involved as ambassadors. This aim was met!"** [Workshop delegates] • Embedding of the Maths Communicators module and launch of a Physics Communicators module both at the University of Bath. • Continuance of the Communicating Science Module at Bristol (set up as a first year Physics option as part of the project). • Continuance of the IoP's voluntary STEM Communication activities across the region. • On-going demand for the Student Science Communicators at UWE. • The creation of Bath's new Public Engagement Office and the support of the University's Widening Participation unit.

[24] http://www.hestem-sw.org.uk/project?id=12

Case Study 17: Developing Strategic Relationships – Teacher and Industrial Advisory Boards

Activity:	Teacher and Industrial Advisory Boards
Institution(s):	TABs: University of Birmingham, University of Bolton, Cardiff University, Coventry University, University of Greenwich, University of Kent, University of Nottingham, University of Reading, and Sheffield Hallam University IABs: University of Bradford, University of Hertfordshire, University of Hull, Kingston University London, London Metropolitan University, University of Manchester, and University of York TABs & IABs: University of Leeds, and University of the West of England
Activity Description:	13 Teaching Advisory Boards (TABs) were established across a range of disciplines with a remit to enable higher institutions to explore the interface with schools and colleges, help STEM departments keep abreast of changes to A-level systems, and enable admissions priorities within the admissions systems of universities to be communicated to schools. Similarly 9 Industrial Advisory Boards (IABs) were established to help enhance STEM careers awareness in undergraduate students and to advise on higher education curriculum developments to better meet the needs of employers.
Outcomes:	• Academic staff participating in the TABs have reported an increased awareness of changes in 14-19 education landscape. • TAB activities have resulted in changed practices. For example, at the University of Reading different types of outreach activities have been planned informed by practice and curricula within schools and at the University of Nottingham (Physics) more careers advice is being included in outreach lectures, and at the University of Birmingham. • The higher education institutions involved have demonstrated a commitment to continuing the TABs. • At London Metropolitan University the IAB reviewed the mathematics curriculum which has since been recently revalidated. Guidance on establishing an IAB was developed which was used to support the other mathematics departments later establishing an IAB.
Legacy:	**“We now have a better understanding of the various non-traditional routes to HE taken by college students and have put in place specialist support structures for these student prior to entry to HE. We also have recently (May 2012) revalidated our Engineering Foundation year and Degree Programme in line to help the smoother transition for students based upon our discussions with our local colleges.”** [Academic Member of Staff, University of Bolton] **”…the School has committed to ensuring that the TAB can continue on an annual basis as part of the School’s good governance.”** [Academic Member of Staff, Cardiff University] **“We have revised our programme of Engineering schools’ liaison activities and have invited the TAB partners to be partners and attendees in future events.”** [Academic Member of Staff, University of Kent] **“The sustainability of these activities will be supported by a new education engagement officer in the Faculty.”** [Academic Member of Staff, University of Leeds]

Case Study 18: Working Across the School-University Interface

Activity:	Supporting Student Transition to University
Institution(s):	Sunderland University, University of Sheffield
Activity Description:	A successful transition from school/college into university, which involves a huge change in lifestyle, culture, experience and learning methods is key in ensuring students have a positive and enjoyable experience of higher education. As they start university, students enter a new way of learning, have high expectations placed on them and have their own high expectations of the environment they are entering. The experience of current students is often very different to that of staff when they entered university life and so mismatches in expectations between students and staff are likely. This project mapped the curriculum and staff-student expectations via a teacher fellowship scheme. In contrast to the RSC scheme, the teacher fellows in this scheme remain in school.
Outcomes:	University of Sheffield • The gaps and overlaps between A-level and Level 1 will be addressed by a number of relatively small modifications to Level 1 syllabuses and through changes to the induction programme. • Changes to Level 1 tutorial programme in Mathematics mean that all academic staff will be involved with Level 1 students and will be given copies of the mapping and stylistic differences documents and encouraged to reflect on gaps and overlaps and to address these accordingly. • The mapping documents will also be of benefit to postgraduate tutors and will be disseminated to them during their own training programme. • Better dialogue between schools/colleges and the University has helped develop valuable partnerships. University of Sunderland • Prior to undertaking the STEM project the University had, had no collaborative partnership with the College in the area of engineering; the project has enabled dialogue to occur. • The review undertaken of the recent retention patterns across the University's engineering programmes has suggested that diploma students entering HE undergraduate programmes in engineering may be at greater risk of early withdrawal than A level students and so may need extra support and this project has enabled an analysis of this.
Legacy:	• The School Mathematics has been selected as the new regional base for a Further Mathematics Support Network Coordinator. The Faculty of Science is providing additional funding to expand the role of the appointee to include 0.4 FTE working as a Schools Outreach Officer who will play a key role in disseminating the results of this project and in shaping their transition management in the future. [Sheffield] • The University itself is conducting a substantial review of its role in the entire transition process for undergraduate students. This project will be an example of good practice. In addition, this project is to be replicated within other departments within the Faculty of Science in 2012/13. [Sheffield] • The gaps highlighted between the engineering curricula at FE and HE through the mapping exercise will be addressed in the University's Engineering subject review to be undertaken in the academic year 2012/13. [Sunderland]

Case Study 19: Working with Primary Schools

Activity:	Using Drama and Workshops to Engage Primary School Children with Science
Institution(s):	University of Hull, University of Bradford, Double Take Theatre
Activity Description:	A play aimed at Key Stage 2 children was written in which the central characters use simple science, technology and engineering methods throughout their adventures. In so doing it is hoped that the audience will be inspired to emulate the characters, in much the same way that every child who has read a Harry Potter novel wants to perform magic. The audience is then given the opportunity to do just that in workshops that immediately follow the play. The science methods consist of techniques that can be easily performed safely in the home, such as film canister rockets (powered by vinegar and baking power), electromagnets (constructed from a nail, a coil of wire and a battery) and a pH indicator made from red cabbage. This shows children and parents how accessible science can be and how easily science experiments are.
Outcomes:	• Resources that describe the methods in a way that is easily accessible to school children accompany the play. This has been achieved by producing instructions in a comic book format[25] • The play has engaged primary school children in 10 schools in STEM subjects via drama and workshops which demonstrated the accessibility and excitement of STEM. The workshops were delivered to Key Stage 2 pupils after viewing the play.
Legacy:	• The comics have been deployed at science festivals, shopping centres and family learning workshops throughout Yorkshire and the North East. The Sci-toons website receives a steady stream of about 100 visitors per month. • Several Local Authorities have become involved and booked the play and workshop for their own schools.

[25] http://www.sci-toons.co.uk/

Case Study 20: Institutional Perspectives – Public Engagement

Activity:	Transferring the Magic to STEM
Institution(s):	Queen Mary, University of London
Activity Description:	An extension of the idea of using magic as a tool to interest students about STEM and to engage a wider audience to be aware of the secret science behind magic tricks.
Outcomes:	• Approximately 150 students engaged by 3 national shows. • 3,600 views on YouTube and 1,149 website hits as of September 2011. • The resources are developed and the website will be maintained after funding stops as part of the Faculty outreach strategy. The Illusioneering project will feature in faculty publicity materials and as part of faculty outreach work. • Additional funding has been secured from the QMUL Science and Engineering Faculty to develop a printed book of the resources for schools which will be distributed through faculty teacher events in various schools. • Four staff members have been mentored on making science teaching interesting and accessible through the experience gained on this project.
Legacy:	• Successful EU Grant (FP7 Science in Society) based upon the Illusioneering project entitled 'Teaching Enquiry with Mysteries Incorporated which will establish a pilot teacher training programme for current and future teachers. • Following the RCUK call for Public Engagement with Research Catalysts, QMUL was successful in securing funding to establish a Centre for Public Engagement[26]. • The lead of this National HE STEM Programme project, and lead for the London region More Maths Grads pilot was appointed to the role of Vice Principal for External Partnerships and Public Engagement at Queen Mary in January 2012.

[26] http://www.qmul.ac.uk/publicengagement/

Case Study 21: Institutional Perspectives – Coherent STEM Strategies

Activity:	Constructing a Coherent STEM Strategy with Schools
Institution(s):	University of the West of England and University of Plymouth
Activity Description:	The University of the West of England runs a number of STEM outreach activities in mathematics, but felt they were not integrated. By working collaboratively, the University sought to embed good practice from the University of Plymouth regarding their coherent STEM approach to school liaison.
Outcomes:	• UWE ran one pilot STEM Activity Day based on the University of Plymouth STOP day at Brislington Enterprise College in November 2011. 270 year 8 pupils attended the day. • Since then, in the academic year 2010/11 UWE has run 4 more STEM Activity Days at four separate Bristol schools reaching approximately 1000 Year 8 pupils; undergraduate students have been involved in running the activities. • UWE Mathematics, Engineering and Science students have run the activities on the STEM Activity Days. The experience enhances their ability to communicate their subject with others and is a useful addition to their CV.
Legacy:	**"The UWE STEM Activity Days would not have happened without HESTEM pump finding the pilot project. The pilot project gave us the means to experiment and try things out. We now have in place a very successful outreach activity which is promoting STEM subjects in schools and encouraging pupils to consider opportunities and careers in STEM areas."** [Academic member of staff, University of the West of England] • A further 5 STEM activity days were run in schools in Bristol in May/June 2012, reaching a total of 750 Year 8 pupils. Planning for 2013 is underway.

Case Study 22: Institutional Perspectives - Transfer and Embedding of Outreach Activities I

Activity:	Mathematics Challenge Competition; Hands on Maths Workshops; Maths at Work Day; Science Van/Gwyddfan; Developing a Physics/STEM Roadshow; Mathematics Large OutreaCh Kit (MLOCK)
Institution(s):	Aberystwyth University
Activity Description:	Aberystwyth University implemented a range of activities, first developed through the four disciplinary pilot projects, and with an emphasis upon working with those currently within the school and college sectors. These include Science Van derived from the Institute of Physics' 'Lab in a Lorry', a range of **more maths grads** activities, and most recently acting as a host for one of the Mathematics Large OutreaCh Kits (MLOCK).
Outcomes:	• Over 1000 people interacted with the Science Van and over 650 students from schools and colleges participated in the 2011 mathematics activities. Science specific training offered to teachers. • Undergraduate and postgraduate students (minimum of 19) have been trained and supported to deliver outreach activities; 16 new STEM Ambassadors recruited. • Materials translated into Welsh and freely accessible to sector. • Two further projects developed from Science Van, and Science Van now forms part of a wider offering to include mathematics roadshows. • 38% more schools attended Science Week activities at the University after a visit from the Science Van. Increased engagement by local employers with both the University and local schools after their participation in the Science Van Project.
Legacy:	**"We have changed our evaluation and also the way in which we offer sessions as outreach."** [Academic Member of Staff, Aberystwyth University] • The activities implemented now form a core part of the provision offered by the University[27] and were successfully offered again in 2012. • The 2013/14 Aberystwyth Fee Plan Agreement[28] notes: **"The mentoring scheme uses our undergraduate and postgraduate students in mentoring activities, working one-to-one or one-to-two on a weekly basis with students who have been identified by the schools as at risk of low attainment in Mathematics or Science subjects…. We will monitor the success of this programme at the end of 2012/13 and will seek to further develop the programme. In 2013/14 we will be looking to expand the range of subject areas, to include mentoring students in English."**

[27] http://www.aber.ac.uk/en/widening-participation/schools/stem/

[28] http://www.aber.ac.uk/en/media/student-fees-english-2013-14.pdf

Case Study 23: Institutional Perspectives - Transfer and Embedding of Outreach Activities II

Activity:	Chemistry Outreach Package; Spectroscopy in a Suitcase; Eisteddfod 2010; Interactive Welsh and English Periodic Table
Institution(s):	Bangor University
Participating Department(s)	School of Chemistry
Activity Description:	Bangor University has implemented a range of Chemistry focused activities to enhance its work with schools and colleges. The Chemistry Outreach Package and Spectroscopy in a Suitcase, were adopted from the Royal Society of Chemistry's **Chemistry for our Future** initiative, Eisteddfod 2010 enabled the department to provide new activities to showcase STEM at the 2010 festival, and a bilingual periodic table was developed for use in undergraduate level teaching.
Outcomes:	• The implementation of the Spectroscopy in a Suitcase Initiative within 2 HEIs in Wales (Bangor and Cardiff) resulted in the guidance materials being translated into Welsh. • 190 students from 13 schools and colleges participated in the Chemistry Outreach Package activities, and the modification of the activity enabled 50 students to achieve a British Association Bronze CREST Award. • The Interactive Periodic Table is utilised with students on the Access Course with non-chemistry specialists, at GCSE revision days, and the Eisteddfod Festival.
Legacy:	**"The importance of the bilingual periodic table cannot be underestimated as the portable table will be used at Welsh language events to promote Bangor and its Welsh language policy and the teaching of Chemistry through the medium of Welsh at degree level."** [Academic Member of Staff, Bangor University] • Spectroscopy in a Suitcase continues to be offered to local schools for 2013/14 and participation in the Eisteddfod Festival is a core part of the Department's outreach activities[29]. The Chemistry Outreach activities continue, and have been adapted to enabled students to achieve a British Association Bronze CREST Award.

[29] http://www.bangor.ac.uk/chemistry/documents/Chem%20Sch%20evs%20prog%20Oct%202012.pdf

Case Study 24: Institutional Perspectives – Strategic Approaches to Regional Working

Activity:	Self-Sustaining STEM Networks – Widening Participation in STEM Through Engaging with School and College Students
Institution(s):	University of Chester
Activity Description:	The main aim of this project was to provide Cheshire and Warrington school and college students with a direct link to industry, with a view to developing a better understanding of STEM career options, skills needs, opportunities for career progression and routes to higher level study. At the heart of this project, therefore, was the development of improved networking between universities, schools/colleges and local employers.
Outcomes:	• A new programme to profile STEM-based career opportunities developed which includes school/college students attending STEM workshops at the University being offered 20 UCAS points. • Student-employer workshops for Year 12 & 13 students have engaged 342 young people from 5 schools; 76 students attended a Year 10 STEM awareness week; 15 teachers from 13 schools attended a Teacher-Employer workshop that resulted in better links with school STEM clubs; employers, STEM Ambassadors and undergraduate science buskers were brought together to provide a conference workshop for Year 10 students. • 11 additional employers engaged to provide careers information at future events; 23 video snapshots recorded of employers talking about STEM skills and career opportunities. • Several faculty staff have become STEM Ambassadors, and undergraduates have become STEM buskers assisting with STEM workshops and science projects in local primary schools. • Undergraduates now have the opportunity for visits and placements in the NHS microbiology laboratory.
Legacy:	**“The success of the STEM Awareness Week means that it is now embedded in the University Widening Participation programme, together with Higher Level workshops. Closer working relationships with colleagues in the faculty will ensure the continuation of the undergraduate bioscience workshop to raise awareness of graduate careers. The teacher/employer workshops will also continue and with increased efforts to engage more schools and teachers.”** [Academic Member of Staff, University of Chester] • A STEM conference to celebrate International Women’s Day on 8th March 2013 has been arranged, and a ‘Women in Science and Technology’ Group established with 23 members to explore gender issues and encourage more female undergraduates in the STEM disciplines. The intention is to apply for the Athena SWAN charter. • Chester is working in partnership with employers in England and Wales, Glyndŵr University, Reaseheath College and West Cheshire College, in developing higher level, STEM qualifications for work-based learners and for continuation from the Advanced Apprenticeship Programme. • The possibility of an eighth faculty at the University for Specialist Engineering Qualifications and research is under discussion.

Case Study 25: Widening Participation Through Lifelong Learning

Activity:	Connect to Science
Institution(s):	University of York
Activity Description:	Many adults in our community are disengaged from science. Despite numerous regional and national programmes aimed at progressing adults into degree level courses the step towards a Foundation Degree is too great for many learners. **Connect to Science** aimed to re-engage adults with science and mathematics, introducing key topics using creative writing techniques to be more accessible to those without prior science education. The National Science Learning Centre (NSLC) hosted the class-based activities and the course was created and delivered jointly by a Department of Physics tutor and a creative writing tutor from the Centre for Lifelong Learning. Class-based activities were supplemented by visits to practical science locations such as a Drax power station and the National Railway Museum.
Outcomes:	• A total of 68 students participated in the six times the course was offered during the 2011/12 academic year. • Course evaluations present strong evidence that not only has interest in science been developed but that pathways to progression have been actively sought by students. • An increased scope of the science curriculum within the Centre for Lifelong learning, and a closer working relationship between the Centre and the Department of Physics. • Future projects will include a more sustained initiative aimed at secondary school parents.
Legacy:	**"The visibility of the National Science Learning Centre has been increased making it accessible to non-traditional learners and closer relationships with city partners such as York Museums Trust and the National Railway Museum have been developed. The project has been nominated for a Vice Chancellors Gold award for Inclusivity and one of the students recently won 'York 2012 Adult Learner of the Year'."** [Academic Member of Staff, University of York] **"…work is already underway to offer a 10 week evening class programme to parents of key stage 3 and 4 pupils so that they can better support their children's careers aspiration in STEM related topics, entitled 'Science is for Parents Too'…This has been consolidated by an application to the Wellcome Trust for funding to support a pilot programme for the parents of key stage 2 children which, if successful, could be rolled out nationally via the regional Science Learning Centres. Funding has also been won from NERC for a series of one-off workshops in science entitled 'Simple Science'"** [Academic Member of Staff, University of York]

Case Study 26: Creating and Disseminating Resources for use by those in the Pre-University Sector

Activity:	Enhancement of the Mathscareers Website[30]
Activity Description:	A priority identified for continuation from More Maths Grads was the continued development of the Council for the Mathematical Sciences Maths Careers Website given the prior absence of a mathematics specific resource. The Mathscareers Website operates at a national level and includes a Welsh language section. The major aim of the website is to deliver high quality information to raise the profile of the study of mathematics and the careers that are possible with good mathematics qualifications, across a wide age range.
Outcomes:	• Visits to the website each month have increased from 6,200 in February 2010 to 16,300 in June 2012. • A new section 'HEI/Ambassadors' was introduced in 2011 supporting the work of University Maths Ambassadors established through the Programme, and the developed Careers Quiz. • 123 articles produced through the Programme explaining applications of mathematics in a range of differing contexts. • 25 information and advice pages for students have been added to the website, along with 27 careers profiles. • Approximately 100 video resources added to the website by the end of the Programme.
Legacy:	**"All resources from the Programme are available from the website and the legacy will be held indefinitely."** [Institute of Mathematics and its Applications Representative] • A collaboration with the Millennium Mathematics Project[31] has enabled the sharing of resources; referrals from Plus Magazine have increased from 30 in May 2012 to 384 in June 2012.

[30] http://www.mathscareers.org.uk/undergraduates.cfm

[31] http://mmp.maths.org

Case Study 27: Support at the Transition – trans:it

Activity:	Development of a suite of materials to support transition from vocational courses to HE
Institution(s):	University of Bradford
Activity Description:	Students making the transition from vocational to higher education provision often experience difficulties arising from factors such as their more diverse course and qualification background and the greater variety of modes of study or assessment than is general in their earlier studies. The trans:it activity based at the University of Bradford arose in response to these observations, and through a suite of support materials for both the students and their tutors it aims to support the transition of school and college students from BTEC and other vocational courses into HE science and engineering courses.
Outcomes:	• The trans:it resource is now of greater use for existing students in the early stage of their course, for those on foundation year or foundation degree provision and for applicants preparing for their course of study. It is used regularly in a number of universities and further education colleges. Students who are more informed and better prepared for the demands of higher education courses in physics, chemistry and engineering, in the long term lead to improved levels of attainment and retention. • FE and HE tutors who are more aware of the approaches to their subject matter in different sectors; • Improved dialogue across sectors of education. • Additional web- and paper-based material specifically for students moving from school or college science courses (especially BTEC Applied Science) to physics and chemistry courses at higher education level have been developed along with a supporting programme of tutorial activities, and a guidance pack supporting the programme and the materials.
Legacy:	**“We have just enrolled on pilot e-portfolio project with 70 students and if this proves successful we will be rolling it out to all students next year and trans:it fits well into the personal planning element of the e-portfolio.”** [Senior Careers Advisor, Huddersfield New College] **“I used parts of your material to add to a course on ‘Advanced Essay Writing’ to our international/EU students studying on various degrees at the University of Portsmouth.”** [Member of Staff, University of Portsmouth] As a result of the activity the University of Bradford has a set of support resources (freely available under Creative Commons licensing arrangements) for students anywhere to use in either supported or independent learning, and for tutors to incorporate into tutorial or other support provision. The material is accessible online[32], and uptake data shows usage from across the world in a variety of learning institutions and contexts.

[32] http://www.transit.ac.uk

Case Study 28: Mathematics Support at the Transition to University Study

Activity:	Provision of Extra-curricula Mathematics and Statistics Teaching and Learning in Higher Education Institutions
Institution(s):	Led by **sigma**, a Network that grew from the **sigma** CETL programme and led by Coventry and Loughborough Universities. Active involvement of over 90 institutions.
Activity Description:	The sharing of experiences and good practice as widely as possible to ensure that students at all levels of study and achievement benefit from academic support in addition to that provided as part of their course. Activities related to maths support included the establishment of new maths support centres and enhancement of existing provision, development of resources to support both students and those providing maths support and a variety of networking and training opportunities.
Outcomes:	• 14 new maths support centres established in England (2588 students supported) and 8 new centres in Wales. • Enhancement of provision at 6 existing maths support centres (138 additional students supported – but not all enhancements aimed to increase numbers). • Development of a network across England and Wales (Case Study 29). • Provision of subject specific maths support resources including Facts and Formula leaflets. All resources are hosted, and freely accessible, on mathcentre[33] and statstutor[34]. • Support for specific projects including the Midland Regional Dyscalculia Centre, creation of datasets for use in demonstrating statistical descriptions and tests and testing, and provision of distance support. • Workshops/training for those working in maths support centres including resource development and training of Postgraduate students who work in maths support centres. • Guides for those working in maths support centres including how to set up provision, gather feedback and undertake tutoring. • Two major research projects to inform understanding of the development of maths support – a review of relevant academic literature and an analysis of the extent of current provision. • 3 national conferences on mathematics support (CETL-MSOR). • Attendance at events by representatives of 89 English and Welsh institutions and 12 from Scotland and Northern Ireland.
Legacy:	**"…these clinics are developing into an integral and vital part of student learning support at the University of Kent…"** [Corporate Services Member of Staff, University of Kent] **"…I consider the first year of the Maths Skills Centre to have been a great success…"** [Deputy Vice-Chancellor, University of York] **"I'm very pleased to say that the centre has already proved its worth in the first year."** [Vice-Chancellor, University of Lincoln] • Continued maths support provision offered at all institutions in 2012/13 supported by **sigma**. • Continuation of a vibrant Network (Case Study 29). • Continuation of the annual conference (CETL-MSOR 2013 to be held at Coventry University 10-11 September 2013). • Resources and lessons learnt available on the **sigma** website[35].

[33] www.mathcentre.ac.uk

[34] www.statstutor.ac.uk

[35] www.sigma-network.ac.uk

Case Study 29: A Community-wide Approach to Mathematics Support – The sigma **Network**

Activity:	Creation of the National **sigma** Mathematics and Statistics Support Network
Institution(s):	University of Bath – South West and South Wales Hub (17 Institutions) University of Leeds and the University of Sheffield – North East and Yorkshire Hub (10 Institutions) University of Liverpool – North West and North Wales Hub (12 Institutions) University Campus Suffolk – Eastern England Hub (10 Institutions) Brunel University – South East Hub (9 Institutions) Coventry University and Loughborough University – Midlands Hub (14 Institutions)
Activity Description:	Establishing six regional hubs each of which: • Promoted and hosted local events, each of which was evaluated. • Developed a network to support members and encourage collaboration. • Provided regular updates for the Network website[36] and e-newsletter. • Contributed to the annual CETL-MSOR Conference (Case Study 28).

Outcomes:	• Enthusiastic practitioners willing to share experiences and specific expertise demonstrated by involvement as project mentors to support the establishment of new maths support centres.
	• Varied programme of events often attended by representatives from other hub areas, these included:
	  • Events focusing on particular issues such as statistics support, mathematics support for nursing and midwifery students, development of resources.
	  • Regionally focused events e.g. Eastern England Hub event to support Anglia Ruskin University which was at the time in the process of establishing a maths support centre
	  • Discussions of new initiatives and approaches including on-line resources such as MathsEG.
	• Attendance at hub events by representatives of 45 English and Welsh institutions.
	• Collaboration between institutions e.g. Leeds, Loughborough, Sheffield and York jointly developed a collection of discipline specific datasets for demonstrating statistical tests to be made widely available[37] and a summer student intern scheme in the South West[38].

Legacy:	• Continuation of a vibrant Network with a new management structure involving representatives from all hub areas. • All hub co-ordinators have agreed to continue facilitating regional hub events on a voluntary basis. • Topics for events planned for 2012/13 include supporting students to develop statistical skills, dyscalculia, undertaking pedagogic research and accessible learning resources. • Organisation of the CETL-MSOR 2013 conference to be held at Coventry University 10-11 September 2013.

[36] www.sigma-network.ac.uk

[37] www.statstutor.ac.uk

[38] http://mathstore.ac.uk/headocs/Proceedings2011.pdf

Case Study 30: Institutional Perspectives - Mathematics Support

Activity:	Establishing a Mathematics Support Centre
Institution(s):	University of York[39], University of Warwick[40]
Activity Description:	Each institution was required to provide matched funding and evidence of institutional commitment. The University of York was supported for two years and the University of Warwick received funding towards the end of the National HE STEM programme as effective practice was being further rolled-out. During its pilot in the 2010/11 academic year, York's Maths Skills Centre offered drop-in support and bookable appointments to first year students studying subjects that taught, or assumed knowledge of, algebra and/or calculus. Following success of the pilot support is now available to all students at the University, but priority is given to first year undergraduates (via a queuing system). Throughout the year, various workshops are available on a sign-up basis e.g. descriptive statistics and hypothesis testing. Support is provided by a dedicated full time Project Officer and trained Postgraduate teaching assistants. The Quantitative Biology Centre (QuBiC) at the University of Warwick provides support for students in the School of Life Sciences in quantitative science methods that underpin modern biological and biomedical science. It provides a drop-in centre for undergraduate and taught postgraduates and mentoring and higher level training to research students. The PhD and MSc Project Advice Desk was launched in mid-April 2012 and an undergraduate final Year Project Drop-In run for 6 hours a week for 6 weeks during May and June. In 2012/13 this provision has been extended to include a general drop in for undergraduates and MSc students open on a daily basis in term time.
Outcomes:	University of York • 591 total student visits (143 unique visits) in 2010/11 and 407 total student visits (167 unique visits) in 2011/12. **"I find the Maths Skills Centre a lot more helpful [than problem classes]. It's every day of the week that you can go, and they can help you with whatever you're struggling with."** [Physics student, University of York] **"Especially in the second term it [the Mathematics] is very difficult. There's nothing I can't learn, but it's taking a lot of time. That's why I've been going to the Maths Skills Centre."** [Foundation Electronics student, University of York] **"We asked our tutor if there was any chance of extra maths tuition…we were feeling out of our depth. He basically said 'No, but there is this Maths Skills Centre, why don't you go along?'"** [Astrophysics student, University of York] University of Warwick • 53 MSc/PHD project appointments (23 unique visits) and 53 total student visits (29 unique visits) to the undergraduate final project drop in during the 2011/12 final term. • Very positive feedback from students including that that they would recommend use of to their friends in lower years. • Positive feedback on the value of this support, and value also noted for a few specific projects during discussions in the Final Year Exam Boards. • Through discussions with one of the consultant statisticians, a PhD student developed a novel analysis approach to detect differences in response along a time series, particularly being concerned with the identification of times at which treatment responses diverge. This approach, applied to assessment of herbicide resistance, has allowed the determination of the times at which plant populations have started to show evidence of herbicide resistance under a range of different scenarios, and will be published (with the statistician as a co-author) prior to completion of the PhD.

Legacy:	• Institutional buy-in, continued funding and commitment to improving delivery of Mathematics Support at both Institutions. • One of the aims of the University of Warwick project is to inform the potential development of associated mathematics support facilities within other University departments. • Inclusion in the University of York's 2011/12 and 2012/13 OFFA agreement and in the QAA institutional review self-evaluation document as evidence of steps taken to improve the quality of students' learning opportunities. • Inclusion of the University of York's project's evaluation methods in AMOSSHE's Value and Impact (VIP).

[39] www.york.ac.uk/maths-skills-centre

[40] www.warwick.ac.uk/fac/sci/lifesci/study/qubic

Case Study 31: Transfer and Embedding of Stimulating Physics Project Activities – Problem Based Learning

Activity:	Problem Based Learning and Conceptual Understanding in Physics
Institution(s):	University of Leicester (lead), Durham University, University of Edinburgh, University of East Anglia, University of Hertfordshire, University of Hull, London South Bank University, University of Salford, University of St Andrews
Activity Description:	Problem based learning (PBL) offers students a different approach to learning than the traditional lecture or laboratory class. Gains for students include increased employability skills, improved understanding and knowledge retention and a more flexible approach to problem solving. At the University Leicester, PBL is used as part of the physics degree in group-based laboratory classes and projects. It also runs an innovative PBL based Integrated Science course, which works across STEM disciplines, and is largely taught though PBL, and PBL is used extensively at London South Bank University and the University of Salford as part of its new-look physics degree (Case Study 32). A related large scale curriculum project was established, led by the University of Leicester, which addressed a perceived weakness of physics undergraduate programmes in developing students' conceptual understanding and ability to formulate and analyse physics models.
Outcomes:	• Leicester has developed a model for delivery of PBL courses that is less intensive on the time of academic members of staff. • An internal review demonstrated high levels of student satisfaction with the PBL approach and the Integrated Science course. Academic staff are also happy to engage in teaching using PBL methods. • An online guide and tools, 7 workpackages, for evaluating conceptual understanding (concept inventories) and materials to support conceptual understanding that can be used in a variety of context from lecture support to self-help[41]. • Implementation of the tools to support conceptual understanding at 5 higher education institutions.
Legacy:	**"Problem Based Learning within physics teaching at UEA will be more common in the future as a result of this case study."** [Academic Member of Staff, University of East Anglia] **"Their experience of the lab has changed quite considerably since we introduced this initiative."** [Academic Member of Staff, Durham University] **"…very encouraging, as you don't always get such a gain after a lecture course."** [Academic Member of Staff following implementation of conceptual understanding tests] **"The lead University has already initiated a new project with the IoP on support for a new curriculum for Quantum Mechanics to do specifically with conceptual understanding, thereby providing an important spin-off."** [Academic Member of Staff, University of Leicester] • 15 complete physics-based PBL learning modules are available for departments to utilise[42] and a 'how-to' guide for PBL has been produced • The lead developer of PBL materials at Leicester has worked with a number of departments setting up or reinvigorating their physics degrees. They include London South Bank University, the University of Bradford, the University of Portsmouth, the University of Salford, the University of East Anglia (who adopted PBL through the Menu of Activities initiative), and the University of Liverpool. This support continues through an ongoing PBL summer school[43]. • A 2012 internal review of Leicester's Integrated Science course has seen it endorsed by the University and it will continue to be supported. An increased marketing focus will see it being rebranded as Natural Sciences with the aim of expanding the number of students admitted.

[41] http://www.physics.le.ac.uk/physicsconcepts/index.shtml

[42] http://www.iop.org/education/higher_education/stem/industrial/page_47362.html

[43] http://www.physics.le.ac.uk/PBLSummerSchool/

Case Study 32: Transfer and Embedding of Stimulating Physics Project Activities – Repackaging Physics

Activity:	Repackaging Physics
Institution(s):	University of Salford
Participating Department(s)	Physics Department
Activity Description:	The physics degree at Salford has been reinvigorated to improve the employability skills and knowledge of students. The project was initiated following market research highlighting the lack of careers awareness of both current and potential physics students. Marketing of the degree has also been refocused to help potential students understand what careers are open to them following study of a physics degree.
Outcomes:	• An observed increase in applications to study MPhys and BSc physics degrees. For 2010 entry, 111 applications were received, and for 2011 entry this had increased to 185[44]. Applications for 2012 entry were 52% up on those for 2010 entry. • The first year course focuses upon employability skills alongside a careers seminar series, and Problem-based learning laboratory work (implemented with support from Leicester) is embedded from the first year. Students participate in Industrial-based group work within the second and third year. • An industrial forum consisting of 17 members has been established to provide guidance. • A guidance document for other departments has been developed[45].
Legacy:	• The new course launched in 2010. Application numbers were up 80% on the previous year and final enrolment numbers were up by 77%. Admittance numbers are now at the maximum for the size of the department.

[44] While 2011 was an anomalously high year for applications to university, this 67% increase compares very favourably to university-wide figures across all disciplines of 32%.

[45] http://www.iop.org/education/higher_education/stem/resources/file_44401.pdf

Case Study 33: Transfer and Embedding of Chemistry for our Future Project Activities – Context and Problem Based Learning (Chemistry)

Activity:	Context and Problem Based Learning (Chemistry)
Institution(s):	Bangor University, Dublin Institute of Technology, Edge Hill University, Glyndŵr University, National University of Ireland Maynooth, Sheffield Hallam University, University of Huddersfield, University of Bradford, University of Central Lancashire, University of East Anglia, University of Edinburgh, University of Leeds, Nottingham Trent University, University of Reading, University of Salford, University of Sheffield, University of Southampton, University of Strathclyde, University of the West of England, University of the West of Scotland, University of Ulster, University of Warwick
Activity Description:	Context- and Problem-Based Learning (C/PBL) aims to increase students' engagement with the subject by delivering courses which are based upon real-life applications of the principles, techniques, and experiments that students encounter in their undergraduate courses. C/PBL provides the opportunity to enhance students' employability skills by fostering the development of transferable skills valued by employers such as communication, team working, and problem solving. In addition to the resources developed through Chemistry for our Future[46], the Royal Society of Chemistry produced 10 further resources. Through a trial process involving 20 higher education institutions feedback was not only obtained on the resources but the process enabled the transfer of good practice from C/PBL experts to novice practitioners and the embedding of this pedagogy into the chemistry higher education curriculum.
Outcomes:	• Resources were trialled or implemented by 23 higher education institutions and approximately 950 students benefited by participation in the activities. • 15 of the 19 individuals who responded to the online survey either 'strongly agreed' or 'agreed' with the statement: **'Our institution will be embedding this and similar resources in the curriculum in the future.'** • 18 of the 19 individuals who responded to the online survey either 'strongly agreed' or 'agreed' with the statements: **'This process inspired and supported me to try some new academic practices'** and **'This process made me want to adapt and adopt some of these ideas in my own practice.'**
Legacy:	**"The trial was a success and it has now become a permanent part of the curriculum."** [Academic Member of Staff, University of Salford] **"We will be adopting this resource into our full second year next academic year."** [Academic Member of Staff, University of Edinburgh] **"Involvement in trial has enabled me to try new teaching approaches…"** [Academic Member of Staff, University of Huddersfield] **Due to the success of the resource, we will continue to use it in the future. The resource has been written into the…module rubric and has just been passed through both the School of Food Science and Nutrition and the Faculty Student Education Committee. Therefore, this resource now forms a permanent part of this module.** [Academic Member of Staff, University of Leeds]

[46] http://www.rsc.org/Education/HESTEM/CPBL/index.asp

Case Study 34: Developing Problem, Context and Puzzle Based Learning Within the Mathematical Sciences

Activity:	Mathematical Modelling and Problem Solving (MMPS); Mathematical Problem-Solving Project (MaPS); and, Problem-Solving in Undergraduate Mathematics (PSUM)
Institution(s):	University of Birmingham (lead), University of Cambridge, Coventry University, Exeter University, University of Leeds (lead) Liverpool Hope University, University of Manchester (lead), Open University
Activity Description:	Mathematical modelling and problem solving was identified as a priority for mathematical sciences community activity following publication of the report 'Newton's Mechanics: Who Needs It?' and during a Programme-led Mathematics Curriculum Summit held in January 2012 where delegates recognised problem-solving as the most useful skill a student can take with them when they leave university. Three linked projects were established where the individual project leads worked together to ensure they complemented, rather than duplicated, each other. MaPS shared current good practice and created a bank of problems and solutions to show the value of problem solving and make it easier for lecturers to incorporate problem solving meaningfully into teaching and assessment. PSUM designed and developed a problem-solving package to enable the embedding of problem solving into courses, particularly through a virtual problem-solving environment and case studies of effective integration. MMPS provided mathematics, physics and engineering undergraduates with the ability to develop mathematical models and apply mathematics to analyse and solve problems in science and engineering.
Outcomes:	• MMPs: A complete 15-credit module developed at Keele University, a modelling and problem solving course within the School of Physics and Astronomy at the University of Leeds, and a modelling focus for the Mathematics Workshop (taken by approximately 300 undergraduates at the University of Manchester). • MMPs: Extension of the scheme through the Programme's Practice Transfer Adopters initiative to involve 13 departments within 6 higher education institutions, including 6 departments at the University of Leeds. • An online portal[47] for the MMPS project aligned with the ESRC funded Transmaths initiative. • Teaching Problem-solving in Undergraduate Mathematics[48] – a comprehensive website containing good practice, advice and guidance on incorporating problem-solving meaningfully into the curriculum that also incorporates case studies identified as part of the PSUM project • MaPS website[49] – containing a bank of problems for use in teaching and assessment of undergraduates. • A virtual problem solving environment containing four starting points including questions, tutor notes and case studies[50]. • Outreach sessions with local schools and colleges involving the Universities of Manchester and Leeds focused upon mathematical modelling and problem solving. The first University of Manchester event engaged 10 teachers and 40 students.

Legacy:	**"The materials for this module will continued to be used for future iterations of this module and it will continued to be offered to first-year single honours undergraduates as an options."** [Academic Member of Staff, Keele University] **"We will continue to run the Mathematical Workshop in its current form for the next few years. However…we intend to introduce a second year course in mathematical modelling...A similar course for MSc students will run in 2012/13[51]."** [Academic Member of Staff, University of Manchester] **"This HE STEM outreach event proved to be a highly successful first step in building an effective bridge at the transition between local schools and the University of Leeds"** [Academic Member of Staff, University of Leeds] **"…we have been working with MEI to promote the A-level extended project…the A-level extended project workshop will hopefully lead to several of the participating students taking up a project in the next academic year."** [Academic Member of Staff, University of Manchester] • The national availability of high quality, easily accessible resources to address a need identified by mathematical sciences departments. • Mathematics in Education and Industry (MEI), who were involved in the MMPS project, have recently been funded by the Government to create a new mathematics course for sixth-form students not studying mathematics at A-level focused upon using mathematics to solve real world problems[52].

[47] http://www.transmaths.org/mmps/

[48] www.mathcentre.ac.uk/problemsolving

[49] www.mathcentre.ac.uk/problemsolving

[50] www.nrich.maths.org/psum

[51] http://www.maths.manchester.ac.uk/postgraduate/pgadmission/applied_ind.html

[52] http://www.bbc.co.uk/news/education-20153731

Case Study 35: Meeting a Need – Real World Industrial Problems for Undergraduate Mathematical Sciences Courses

Activity:	Developing Real World Industrial Problems for Use Within Undergraduate Mathematics Courses
Institution(s):	University of Bristol (mathematics), Plymouth University (statistics)
Activity Description:	Mathematics departments can benefit from real problems drawn from industrial contexts but the process has two main problems: the difficulty of finding and engaging with industrial partners; and, matching the difficulty of projects to undergraduate level. The HE Mathematics Curriculum Summit held in January 2011 recommended the development of a bank of industry-based problems, suitable for undergraduate students, developed in consultation with industry partners and vetted. The University of Bristol created an online repository of industrial case study problems, suitable for use throughout mathematics undergraduate programmes. The wiki website divides projects into three categories: introductory, intermediate and advanced, intended to correspond loosely to the first, second and third years of UK mathematics undergraduate study, with currently around 20 fully documented projects within each level. Plymouth University engaged with an industrial/business partner to identify thirteen real problem scenarios with many instances of each available via randomly selected data sets with solutions available to tutors. These are solvable using data interrogation, graphical and statistical modelling methods and have been synthesised into formats for teaching at three levels.
Outcomes:	• An Industrial Problems for HE Mathematics wiki[53]. Access to view these problem briefs is open, where this is possible, without compromising problem solutions. • Industrial problems for the HE Curriculum in Statistics[54]. A password is required, which is freely accessible to those within UK higher education. • Reports from both projects are available in Employer Engagement in Undergraduate Mathematics[55] and an Industrial Problems in Statistics full report is available[56].
Legacy:	As these projects were completed in June 2012 it is too early to assess take up, but the resources were developed in response to an identified need by the mathematical sciences community itself. The mathematics wiki will continue to be developed and is designed to accept new problems from the community.

[53] https://wikis.bris.ac.uk/display/ipshe/Home

[54] http://www.rsscse-edu.org.uk/

[55] www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

[56] www.rsscse.org.uk/images/files/pdf/activities/CaseStudy-STEM-Industrial-Problems.pdf

Case Study 36: A Physics Community-wide Approach – Industrial Group Projects

Activity:	Industrial Group Projects
Institution(s):	University of Bath, University of Birmingham, University of Bristol, University of Cardiff, Durham University, University of Exeter, University of Hertfordshire, University of Hull, University of Kent, Lancaster University, University of Leeds, University of Leicester, University of Liverpool, University of Central Lancashire, University College London, University of Oxford, University of Portsmouth, Queen Mary University of London, University of Surrey, University of York,
Activity Description:	Industrial Group Projects aim to increase the employability of physics graduates by increasing their skills and knowledge of industrial work practices. Students solve real industrial problems, gaining transferrable skills in teamwork, project planning and reporting, while widening their understanding of their career options. Working with the physics department at Durham University, who have successfully run these projects for 20 years, nine physics departments were recruited to trial these schemes with 3rd year undergraduates in 2011/12. Ten more departments are running the projects with their undergraduates in 2012/13.
Outcomes:	• Nearly half the physics departments in the UK (and more than half in England and Wales) have adopted the Industrial Group Projects scheme. • Approximately 70 students participated in the trials during 2011/12. • A wide and varied range of external clients were recruited. Examples include: Multi-national companies (Siemens), SMEs (Graphic PLC), Transport Authority (MerseyTravel), Educational company (E-chalk), Governmental Bodies (NHS), Non-commercial organizations (Leicester Bee-Keepers). Many worked with their respective universities for the first time.
Legacy:	• All physics departments involved in the initial trial in 2011/12 are continuing with their schemes and intend to grow the numbers of students participating. • Following the success of the trial stage, significant demand was received by HEIs wishing to participate; 10 further HEIs were identified who are now running the projects in 2012/13. • The Institute of Physics will continue to support the group of co-ordinators at the universities; other joint areas of interest, such as laboratory classes, are now being discussed. A guide to running the scheme has been developed. • Several universities are seeking to broaden the scheme. For example, the University of Leicester is aiming to expand the scheme to mathematics undergraduates.

Case Study 37: Institutional Perspectives – Industrial Group Projects

Activity:	Industrial Group Projects and Communicating Physics
Institution(s):	University of Bath
Participating Department(s)	Department of Physics
Activity Description:	The Department of Physics has implemented and embedded two new modules into its core undergraduate programmes as a direct result of National HE STEM projects: • The development of the **Industry Team Project** module was facilitated through the Group Industry Projects scheme, coordinated by the Institute of Physics (Case Study 36). These projects involve teams of students undertaking a project in response to a real-life scientific problem posed by an industrial client. • The development of the **Communicating Physics** module arose from the **Developing & Enhancing STEM Communicator Models** project[57] (Case Study 16). This module aims to train students in various aspects of communicating physics and gives the opportunity to participate in events, develop their potential as communicators and explore the media and contexts with which they are most at ease. The main rationale for introducing these modules was that they would add significant additional value by making programmes more attractive to applicants, and graduates more attractive to employers. Both modules aim to enhance students' transferable skills, particularly relating to communication, creativity, teamwork, independent learning and project management.
Outcomes:	• A team of three students successfully completed the **Industry Team Project** module in 2011/12, working with Visteon Engineering Services Ltd. • Following minor changes after feedback seven students successfully completed it in 2012/13, working in two project groups with Visteon Engineering Services Ltd. and EDF Energy. The Department anticipates that the number of students participating will continue to rise in subsequent years. • The module was evaluated positively by both the students and the industrial partners. **"The course itself is interesting. Aside from being a new course it has the advantages of real life interaction with a company, working on team related skills and writing a report with a broader range than the normal physics report. Working with an outside company is useful to any student intending to apply for jobs but even more valuable to ones who haven't done a placement."** **"Overall, I have found this project to be excellent. Being able to interact with a real company and see physics problems represented on a 'real' life scale was highly inspirational. We have come up with a solution that once placed into a case design could be used all over the world."** [Industry Team Project students] **"This was the first year that both Visteon and Bath have run a joint project, so in many ways this was a test case on which we shall build. Having completed the project both sides are very keen to continue with this and expand it further in the future."** [Visteon Engineering Services Ltd.] • The **Communicating Physics** module is being piloted in 2012/13 Semester 2 with seven students registered. Again, the Department anticipates a greater number of students participating in future years, once the module becomes fully established.
Legacy:	• Both the **Industry Team Project** and Communicating Physics modules are firmly embedded in undergraduate programmes with enthusiastic involvement from staff and students. They will continue to run on an annual basis for the foreseeable future. **"…the Industrial Team Project module is now included as a named module on the BSc and MPhys/MSci programmes of study for all Physics and Mathematics & Physics students; the project has therefore been established as a sustainable part of the Department's provision."** [Director of Teaching & Learning, Department of Physics, University of Bath]

[57] http://www.hestem-sw.org.uk/project?id=12

Case Study 38: Student Engagement in STEM

Activity:	Second Year Mathematics BeyOnd (SYMBΩL) Lectures and Student-led Employability Audit Toolkit
Institution(s):	Loughborough University (lead SYMBΩL), University of Exeter (lead Employability Audit Toolkit), and Adopters: University of Birmingham, University of Bradford, Lancaster University, University of Manchester, Newcastle College, University of the West of England
Activity Description:	The SYMBΩL project set out to address long-standing issues associated with high failure rates on some modules and disengagement amongst part of the cohort of second-year undergraduates. The project enabled student interns to work closely with staff members, advising on enhancements and preparing resources, and the recruitment of 'student leaders' working voluntarily during weekly peer-assisted-learning sessions. The Student-led Employability Audit Toolkit project facilitated collaboration between students, graduate employers and staff to design an audit of the extent to which employability support is currently integrated within the Mathematics, Computer Science and Engineering degree programmes at the University of Exeter.
Outcomes:	SYMBΩL: • Four student interns working upon two 10-credit second year mathematics modules, and 13 students supporting peer-assisted-learning sessions in 2011/12. • Wide engagement by undergraduate students taking the redeveloped modules with the support. 13 screencasts were produced by the 2011/12 interns and records of access to four of the resources for one of the modules on the virtual learning environment show **"they were either viewed or downloaded by the 83 students registered for this module an average of 104 times per video between October 2011 to February 2012."** Additionally, of these 83 students, 57 accessed peer support sessions at least once. • Positive outcomes for the four 2011/12 interns in relation to their mathematical understanding and development of transferable skills. Student-led Employability Audit Toolkit: • 12 students undertook an employability skills audit and produced a final report detailing their findings and making suggestions for improvements in the curriculum. Changes to the provision at Exeter were implemented in response to the audit. • Students participating in audit report that they developed skills which they felt would make them more employable. • Through the National HE STEM Programme Practice Transfer Adoption Scheme the University of Exeter (3 modules being revised) and Lancaster (one module revised) adopted the SYMBΩL initiative, and the Student-led Employability Audit Toolkit rolled out to five HEIs.
Legacy:	**'There is a remarkable improvement on last year."** [Module Leader, Loughborough University] **"The Project has been funded locally for another year. Five student interns for 2012/13 have already been appointed and are now at work producing resources for another two modules selected for the Project's attention next year".** [Academic Member of Staff, Loughborough University] **"A mathematics group project module has been successfully rolled out in response to the student-led employability audit. This module develops some of the employability skills that students saw to be lacking in their programme…In addition, another Mathematics module is in development which will allow the students to act as an 'ambassador for maths' by promoting the subject in schools and assisting in the newly formed Peer Assisted Learning (PAL) scheme at Exeter. This module has also been in response to the student-led audit…."** [Academic Member of Staff, University of Exeter] • A postgraduate research student in Mathematics Education is studying the theme 'students as partners in shaping the teaching and learning of mathematics'; the SYMBΩL project has provided an opportunity to gather and analyse data which has been used not only for his own research, but also to inform the development of the project. • Peer support is being developed in other parts of Loughborough University following an application to the Alumni Fund.

Case Study 39: Institutional Perspectives – The Practice Transfer Adoption Scheme

Activity:	Enhancing the Second Year Experience for Undergraduate Mathematicians
Institution(s):	University of Exeter, Loughborough University (Original Project)
Activity Description:	Following on from a project model which used student interns to enhance mathematics modules at Loughborough University in 2011 (Case Study 38), the approach was adopted by the University of Exeter. At Exeter, six second and third year undergraduates worked on this project for four weeks during the summer 2012 producing a suite of resources for second year maths modules.
Outcomes:	• Collaboration established between Loughborough, Lancaster and Exeter to share ideas and outcomes, including an extension of the PhD research work undertaken at Loughborough to include data collection from Exeter students. • Students produced a range of high quality resources including extension materials for the most able students, as well as more basic support resources. • Students developed employability skills (time management and planning) but also enhanced their mathematical and mathematics communication skills, and gained confidence in their abilities. • Extension of model to a range of other projects.
Legacy:	**"The success of this project has resulted in a successful application to the HEA for funding to expand this model of students as 'co-creators' from Mathematics into other disciplines across the College. We now have a number of groups from medical imaging, physics and engineering all working on the 'co-creation' of student resources...this project has been a really transformative project within the College, changing attitudes and ideas about involving students so directly as partners in learning."** [Academic Member of Staff, University of Exeter] **"Following, this very successful project, a number of projects have since been extended across the College which use this model."** [College Dean of Education, University of Exeter] **"This project has provided a legacy of an excellent set of secondary resources for students on second year mathematics programmes, which will be especially useful to help them cope with the increase in speed and complexity of what it being asked of them during that year."** [Head of Mathematics, University of Exeter]

Case Study 40: Curriculum Change within the Mathematical Sciences

Activity:	2020 Vision: a Curriculum for Mathematics Graduates for the Next Decade; Identifying the Skills Gap for Employers and Mathematics Undergraduates
Institution(s):	University of Birmingham, University of Leicester, Nottingham Trent University
Activity Description:	Three Mathematics Departments within the Midlands and East Anglia region sought to revise or enhance their existing provision with a view to supporting the transition of students to the workplace, and to ensure that graduates possess the skills, abilities and competencies expected by employers.
Outcomes:	• A complete review of the entire University of Birmingham Mathematics degree curriculum for implementation from September 2013 entry. To support these changes increased dialogue achieved with employers through an Industrial Advisory Board and the post 'Director of Employability' has been created. • A range of interventions established at the University of Leicester including: A new third year module 'Business Related Project' in which each student has an external supervisor; an employability workshop run by the local Chamber of Commerce; and, an assessed business game which students play in small teams over a period of a semester. • At Nottingham Trent University engagement with employers informed the redevelopment of a credit bearing module. 60 students participated in an industrial assignment to model the job application process; this then led to the formation of groups that then tackled a collaborative project based on real world industrial examples. A student focused guide on the process of finding, applying for and keeping a job has been developed.
Legacy:	**"…the School has embarked on a full scale revision of the curriculum, in part to respond to needs of the research groups, but also to improve the graduate skills, employability and career awareness of out students."** [Academic Member of Staff, University of Birmingham] **"Our impact on the University has been big as we have initiated a College wide employability group, and this has had a big input into the College learning and teaching strategy. We have collaborated in activities with the Careers Service which have led to new modes of engagement with the world of work which will be spun out to the rest of the University. Students from other departments will take part in our employer-related projects.** [Academic Member of Staff, University of Leicester] **"The work on employability has fed into a wider school review and led to the creation of a final year module in professional skills that has been made available to all disciplines within the school of science and technology."** [Academic Member of Staff, Nottingham Trent University]

Case Study 41: A Community-wide Approach to Assessment

Activity:	Assessment in Mathematics
Institution(s):	University of Birmingham, University of Bolton, University of Bradford, Brunel University, Durham University, University of East Anglia, University of Glamorgan, University of Greenwich, University of Leeds, Kingston University, University of Leicester, University of Liverpool, Loughborough University, University of Manchester, Newcastle University, University of Nottingham, Northumbria University, Oxford Brookes University, Plymouth University, University of Portsmouth, University of Salford, Sheffield Hallam University, Queen Mary University of London
Activity Description:	A series of linked projects focusing upon assessment in mathematics were established through the Programme. The 'Mapping University Mathematics Assessment Practices' examined the current state of assessment in undergraduate mathematical sciences degrees with a view to not only providing a broad overview of current practice but also consideration of future alternatives. It explored e-assessment in mathematics which formed another strand of Programme activity by supporting the extended using of computer-based and online assessment and its extension to new areas. It was noted that there currently existed little sector-wide structured dissemination of current practice which was resulting in a duplication of effort, not only in implementation strategies, but also in the writing of questions and the creation of local a-assessment systems. In recognition of this, a large scale curriculum project was established, led by the University of Leicester, to enable the diverse wealth of sector-wide experience in this area to be consolidated, shared, and jointly reflected upon so that the potential contribution to mathematics and statistics learning and teaching as a whole could be evaluated against the range of departmental contexts and institutional requirements. Additionally, student feedback has long been identified as a priority for activity in the mathematical sciences in response to both the National Student Survey, and the More Maths grads project where when students were asked about how their course could be improved they cited aspects relating to feedback and coursework above all other areas; in response a further large scale curriculum project, led by Sheffield Hallam University, collaboratively explored this area to inform and influence practice.
Outcomes:	• A handbook of assessment practices and exemplars for departments looking to enhance their assessment practices[58]. • 7 institutions either trialling new assessment methods or evaluating existing ones. • E-assessment resources and systems made nationally, and freely available[59]. Adoption of existing systems by the University of Bradford and Kingston University through the Programme's Practice Transfer Adoption Scheme. • Development of a community-wide wiki to enable the sharing of practice relating to feedback[60]. • An online assessment system adapted to enable nursing students to self assess their level of numeracy, and an online decision making tree populated with patient case studies and applied numeracy skills. 13 students piloted the developed resource which has led to a new working relationship between the Department of Nursing and Midwifery and the Department of Engineering Design and Mathematics at the University of the West of England. • Automated assessment and feedback of student Matlab assignments implemented at the University of Liverpool. Now only 1 member of staff is involved in the assessment of 250 student submissions. • At Newcastle University, e-assessment has spread from the School of Mathematics and Statistics to the Schools of Engineering. • In their first year of implementation, diagnostic tests were used at the Universities of Birmingham and Manchester by over 350 students. They continue to be used as part of core teaching. • Increased co-ordination and interaction between those developing or utilising different e-assessment systems in mathematics[61]; a facilitated special interest group has been established following a proposal submitted to the Heads of Departments of Mathematical Sciences.

Legacy:	**"…there was a feeling that for the first time the e-assessment community was coming together with a shared view of how to move e-assessment ahead."** [Academic Member of Staff, University of Leicester] **"Furthermore, given the success in mathematics the university has funded the development of an open-source e-assessment tool, Numbas, that is being used in place of the original system…"** [Academic Member of Staff, Newcastle University] **"This project has raised the profile of CAA within the University of Birmingham…"** [Academic Member of Staff, University of Birmingham] **"The e-assessment project has conveniently coincided with a complete overhaul of the university-wide curriculum at Portsmouth. 'Curriculum 2012' has required the rewriting of many course units and a greater degree of collaboration between staff on new year-long units of study. This has provided a strong incentive for the preparation of new e-assessment learning resources and has helped to make new staff aware of the possibilities that can be opened up by their use."** [Academic Member of Staff, University of Portsmouth] **"Arising from the Leicester case study has been a significant increase in uptake from staff in Mathematics in the use of e-assessment in their courses."** [Academic Member of Staff, University of Leicester] **"This project was really a number of small projects; feedback changes introduced by individual staff or departments."** [Academic Member of Staff, Sheffield Hallam University]

[58] http://www.uea.ac.uk/education/mumap

[59] http://numbas.mathcentre.ac.uk and http://www.mathcentre.ac.uk:8081/mathseg/

[60] http://improvingfeedback.wikispaces.com

[61] http://www.e-assessment.com/resources/hestem

Case Study 42: Sharing Effective Practice to Stimulate New Developments in Employability

Activity:	Developing Graduate Skills within the Mathematical Sciences – Sharing and Encouraging Effective Practice
Institution(s):	Sheffield Hallam University, University of Manchester, Oxford Brookes University, Coventry University, University of Nottingham, Nottingham Trent University, University of West of England, University of Leeds, University of Salford, Birmingham City University, The Open University, University Campus Suffolk, University of Central Lancashire, University of Leicester, Plymouth University, Swansea University, University of Greenwich, Lancaster University
Activity Description:	Sheffield Hallam University led a project that investigated and shared good practice on curriculum interventions aiming to develop graduate skills in HE mathematical sciences programmes. Seventeen short case studies provide examples of developing graduate skills within a mathematical context at a diverse set of fifteen universities. These were shared at a number of 'roadshow' workshops. Three further mini-projects drew inspiration from the original case studies and transferred their ideas to new institutions.
Outcomes:	• A new course at Lancaster University to enhance the communication and speaking skills of undergraduate mathematics students. • The University of Leeds ran and recorded a workshop discussing methods of providing mathematics-specific advice on writing skills. • Production of Developing Graduate Skills in HE Mathematics Programmes[62], and Graduate Skills – Introductory workshop (video)[63]. • Further Work Developing Graduate Skills in HE Mathematics Programmes[64]. • Teaching Students to Write Mathematics (DVD)[65]. • Enhancing communication and speaking skills of maths undergraduates (course pack)[63].
Legacy:	• The three projects at Swansea University (presentation and communication skills) and Greenwich University (linking graduate skills and employment needs and the use of progress files to promote self-reflection) are being repeated and extended in 2012/13. • The communication course at the University of Lancaster will be repeated in future years.

[62] www.mathcentre.ac.uk/resources/uploaded/GradSkills.pdf

[63] www.mathcentre.ac.uk/resources/uploaded/gradskills.pdf

[64] www.mathcentre.ac.uk/resources/uploaded/FurtherGradSkills.pdf

[65] www.kevinhouston.net/dvds/writing-math.html

Case Study 43: Sharing Effective Practice to Stimulate New Developments in Student Engagement – The Maths Arcade

Activity:	The Maths Arcade
Institution(s):	University of Greenwich, University of Salford, Sheffield Hallam University, University of Leicester, Keele University, University of Bath, University of Manchester, University of Nottingham
Activity Description:	The Maths Arcade aims to stretch the most able students and those who have more prior mathematical knowledge, whilst at the same time supporting those with weaker backgrounds or who take a little longer to grasp mathematical concepts. The University of Greenwich had established the first Maths Arcade, providing a venue for mathematical talk, games and problem solving, with a range of strategy board games and puzzles available which are designed to hone and develop strategic thinking. This also encourages staff/student interaction, with academic staff attending and students getting help with tutorial work from peers or staff. The Maths Arcade provision at the University of Greenwich was extended to encourage the students more explicitly to engage with analysing the games mathematically, to enable the transfer of good practice to seven other universities, and develop a national user community.
Outcomes:	• Enhanced Maths Arcade at the University of Greenwich. • Sustainable provision of seven new Maths Arcades which have been adapted to various different local scenarios. • A guide to Mathematics Arcade provision[66] for stretching and supporting mathematical thinking, including case studies from those Universities who adopted the Arcades. • Establishment of a national Maths Arcade user group[67].
Legacy:	**"We plan to relaunch the Maths Arcade at the start of the next academic year with a special session in Induction Week for our new students together with their peer mentors. As well as the games and iPad apps we intend to have a weekly maths puzzle and create a bank of resources that can be used in our outreach activities."** [Academic Member of Staff, University of Manchester] **"The games were also used at our open days. We have had games before but they usually are not seen in the department from one open day to the next. It was good to introduce students to, e.g., Quarto and say that they would get the opportunity to play again if they come to study maths here. Indeed small Quarto sets have been purchased for tutor groups and we will be holding a Quarto competition between tutor groups during induction week."** [Academic Member of Staff, University of Nottingham] • Anecdotal evidence suggests the concept of using strategy games in a social setting to develop strategic thinking is being adopted informally across the sector. For example weekly lunchtime 'games playing' sessions are taking place within the School of Mathematics at the University of Birmingham from 2012/13.

[66] www.mathcentre.ac.uk/resources/uploaded/MathsArcade.pdf

[67] www.ima.org.uk/i_love_maths/games_and_puzzles/the_maths_arcade.cfm

Case Study 44: Sharing Effective Practice Through Partnership and Collaboration – STEM Labs

Activity:	STEM Labs Practice Transfer Partnership
Institution(s):	Reach Out Lab, Imperial College London, University of Bradford, University of Bristol, University of Cambridge, Cornwall campus, University of Exeter, The Crick Institute, University of Durham, University of Exeter, University of Greenwich, University of Leeds, University of Oxford, RI L'Oreal Lab, Sheffield Hallam University, University of Southampton, University of Wolverhampton,
Activity Description:	The STEM Labs PTP activity was developed to support HEI's wishing to establishment or develop a dedicated laboratory for schools and young people using the experience of the Reach Out Lab at Imperial College London. Partnerships were established together with a number of strands of activity led by an individual Institution working with others through sub groups. Individual reports produced were shared[68]. The main activities undertaken were to: • Learn from established lab based school programmes within dedicated spaces; • Explore opportunities for collaboration through sharing of content; • Provide practical consultancy support; • Facilitate feasibility studies based on a charging model for school participation through @Bristol linked to Greenwich and a proposed Medway development programme; • Explore sharing of data sets gathered through common activities as support for better understanding and use of statistics within mathematics and science in schools.
Outcomes:	• STEM active personnel from participating universities and institutions met to scope the range of PTP interactions that might take place through established and proto-STEM Labs; • Sharing of existing practice though visits and exchange of operational information, business plans, staffing and professional development models; • Establishment of a 'swop shop' approach and protocol to enable sharing of activities and resources between contributing Institutions regarding the operation of and potential funding sources e.g. through Section 106 agreements (Planning); • Development and publication of case studies including use of satellite centres; • Development of ongoing collaborations and support for development of plans for new facilities; • An established partnership between the Medway academic group and the University of Greenwich and completion of a study to establish local need for a Stem Lab/Science Centre; • Practical support for the University of Bradford's development (part way through its build programme at the start of the PTP);
Legacy:	**"The ROL [Reach Out Lab – Imperial College London] has partnered with Watford Grammar School to set up a satellite ROL centre in the school grounds. The satellite centre will deliver many of the same activities under the guidance of the ROL but the location now enables schools in Bedfordshire, Hertfordshire and further away from central London to benefit from the activities delivered by the ROL."** [Academic Member of Staff, STEM Labs PTP, Imperial College London] • Increased numbers of dedicated STEM Lab spaces for schools outreach activity on university sites; • On-going links in terms of STEM Lab development projects; • Continued activity on Swap Shop protocols (Wolverhampton); • Collaborative STEM lab developments between Southampton and Imperial; • Delivery protocols to be shared for summer school use of STEM Lab spaces (Exeter/ROL); • Active exploration of potential use of spaces in SLCs (SHU, Durham and Southampton); • Cross link with RCUK-SUPI programmes in Southampton and Imperial; • Link with RSC Lab development in Cambridge; • Ongoing development of the Medway/Greenwich collaboration including consideration of sites, a donor/ sponsorship development plan and continued links with Reach Out Lab.

[68] www3.imperial.ac.uk/outreach/wohlreachoutlab

Case Study 45: Supporting Student Access to STEM

Activity:	Developing Good Practice in Assisting Visually Impaired STEM students
Institution(s):	University of Southampton, Plymouth University, University of Bath, London School of Economics
Activity Description:	The small numbers of Visually Impaired (VI) students in HE mean that it is difficult for teaching staff to gain experience of acceptable reasonable adjustments that can be made. It is also difficult to maintain the collective knowledge base within academic departments or advisory services. There is a plethora of information available, scattered between disability specialist journals, subject specific articles or within the context of legislative guidance. The project[69] identified and built on good practice in assisting students with VI to access and succeed in HE STEM subjects specifically in laboratory work. It provided resources to enable informed decision-making, at the time of transition and through HE to placements and future employment and supported continued professional development of academic staff. The project worked with a range of stakeholders from schools, FE and HE, visually impaired students and their allies. Valuing the student voice was central to this project, and information was collected from STEM students with VI about barriers to participation, positive experiences in HE, and technologies that were identified as having had an impact on their studies.
Outcomes:	• Collation of relevant weblinks and articles on access to STEM for those with a visual impairment. • Production of case studies giving an overview of differing types of visual impairment and issues that impact upon students with VI in education and the personal experience of an academic with a visual impairment who has studied STEM. • Design and delivery of a pre-entry taster event, entitled **Inspiring Students with a Visual Impairment**, for 14 young people with VI (along with their parents, career and SEN teachers) at the University of Bath. A case study on this event was also produced, to capture the process of organising the event, so that other institutions can copy the model. • Development of '**Accessiblog**', a blog providing hints, tips and links to assistive technologies used across universities and colleges to support teaching and learning in STEM subjects. • Production of the **STEM Learning & Teaching Reconfigured**[70] online resource as a ‹one-stop-shop› for those staff involved in admissions, central services, teaching, assessments and placements.
Legacy:	**"My parents didn't want me to go to university because of my disability but I wish I could be a student now. I thought I wouldn't fit in but it is cool to be a student."** [Quote from pupil attending the **Inspiring Students with a Visual Impairment** event] **"Thank you very much for the great day we had in Bath. Our student found it most inspiring!"** [Teacher] **"It was challenging and exciting to work on this project that brought together our University, schools, and community to deliver something wonderful and empowering for youngsters. It also allowed professionals to share good practice and increase our collaboration in the west region."** [Widening Participation Coordinator, University of Bath] • The standalone **Accessiblog** resource will continue to be updated, funded via the University of Southampton's LexDis work as part of the Student Centredness Fund. The **STEM Learning & Teaching Reconfigured** online resource will also continue to be hosted for the foreseeable future. • Another **Inspiring Students with VI** day will take place at the University of Bath in 2013. • The **Your Choices, Your Future** report was acknowledged and disseminated to over 300 learning support and enabling staff at the annual Claro Conference for specialist learning support tutors and enablers supporting HE disabled students. • The online **STEM Learning and Teaching Reconfigured** resource is being disseminated to NADP, NNAC, DSA Assessors, SEDA and AMOSSHE, to ensure that disability professionals, educational developers and heads of student services are aware of the resource. It has been requested by the University of Southampton for use on their PGCAPP and will be on the list of online resources for staff undertaking the PGCAPP at the University of Plymouth.

[69] http://www.hestem-sw.org.uk/project?id=14

[70] http://stem.ecs.soton.ac.uk/

Case Study 46: Institutional Perspectives – Applied Physics

Activity:	Curriculum Change in Laboratory work, Engagement of Industry, Development of Applied Physics degree, adoption of Mathematical Modelling and Problem Solving and adoption of Group Industrial Projects
Institution(s):	University of Portsmouth
Participating Department(s)	School of Earth and Environmental Sciences: Applied Physics
Activity Description:	Portsmouth University integrated several activities in enhancing its new Applied Physics undergraduate degree[71]. Employability, supported by industry and employer engagement, formed the core of the enhancements of the degree leading to the establishment of new approaches to laboratory work, industry lead and co-delivered units, an Industry Advisory Board, industry-based group projects and emphasis on problem-solving through adoption of established good practice activities from Leicester and Leeds.
Outcomes:	• Establishment of an Industry Advisory Board with sustainable engagement of industry in curriculum design and delivery in order to produce graduates better placed to add value in employment. • Applied Physics established as a new physics degree and core part of provision offered by the University. Almost 80 undergraduate students at Portsmouth have benefitted so far from the curriculum enhancements and number of applications is increasing. • 140 credits of new integrated and progressive units developed explicitly integrating employability skills. (Applications and Impacts of Physics, Introduction to Laboratory and Field Physics, Practical laboratory and Field Physics, Applied Physics Modelling, Industry Group Projects, Health Physics). • New industry-related problem-based learning activities have been developed with on-going enhancement and further developments arising from employer engagement. • An Applied Physics degree forum has been established through IOP for institutions to collaborate and share good practice.
Legacy:	**"HE STEM supported activities have been vital in allowing us to enhance the burgeoning undergraduate degree in Applied Physics at Portsmouth through the establishment of strong and sustainable links with employers and other HE institutions. "** [Academic Member of Staff, University of Portsmouth] From September 2013 over 100 students will be enrolled in Applied Physics at Portsmouth with similar numbers at the collaborating applied physics group institutions. The development has been recognised by the University of Portsmouth who are strongly supporting the further development of physics and development of graduate employability. New and sustainable collaborations have been established between higher education institutions.

[71] http://www.port.ac.uk/courses/coursetypes/undergraduate/BScHonsAppliedPhysics/

Case Study 47: Institutional Perspectives - Enhancing Laboratory Provision

Activity:	RELITE: Research-Led Innovative Teaching Experiments – Reinventing First Year Chemistry Laboratory Courses
Institution(s):	Durham University
Activity Description:	The first year chemistry laboratory course at Durham was overhauled to produce an integrated and varied sequence of laboratory activities with a more student-centred focus. Research-, discovery- and problem-based learning (so-called 'XBL') activities were introduced alongside reworked established experiments. Both the teaching philosophy and the schedule moved away from traditional inorganic, organic and physical chemistry sections to be re-organised into 'Skills' (teaching the basic procedures and competencies e.g. using a lab book, writing up an experiment and simple experimental techniques), 'Discovery' (where XBL activities are introduced in more depth) and 'Projects' (where all techniques and skills learned are used to attempt more open-ended investigative activities).
Outcomes:	• Undergraduate students have improved understanding of the role of practical work in their learning, and are demonstrating better technical laboratory skills. • Undergraduates have more opportunities to develop the transferable skills demanded by future employers (such as written communication, group work and critical thinking). • The performance of postgraduate demonstrators involved in the delivery of the course has significantly improved, developing their own transferable skills in the process. • A full induction procedure has been implemented and the sequence of activities carefully planned to facilitate the transition between Sixth Form and University study, with laboratory teaching supplemented by a full suite of online support materials. • The newly designed laboratory course ran for the first time in the 2011/12 with over 230 students completing a full program of pre- and post-lab activities designed to complement their laboratory work. • The postgraduate demonstrator training course was overhauled in partnership with the lab course developments to provide appropriate pedagogical and practical training to graduate students who were to teach in the laboratory.
Legacy:	**"'RELITE 2' is currently running in the second year chemistry laboratories at Durham alongside the second incarnation of RELITE 1. Staff worked collaboratively to ensure that the ethos of RELITE is transferred into the second year courses. There are plans to do the same for the third year courses before October 2013 to ensure that those students taking the first RELITE course in their first year have a similar experience in second and third year."** [Academic Member of Staff, Durham University] • The RELITE first year course continues to run in the first year, with further developments being made post-HE STEM funding to improve assessment and feedback methods. • Graduate students are taking more ownership of experiments and leading the teaching and learning activities in the laboratory. • The teaching of transferable skills including effective teamwork, project planning, report writing, IT skills as well as numeracy and literacy is embedded in the first year laboratory curriculum, as demanded in 21st century workplaces.

Case Study 48: Institutional Perspectives – Recording Lectures

Activity:	Recorded Lectures.
Institution(s):	University of Southampton (Lead), University of Reading (Adopter), Queen Mary London (Adopter), University of Stafford (Adopter) University of Bradford (Adopter)
Activity Description:	A series of first year chemistry lectures were recorded at Southampton and were made available to students online. An evaluation was carried out to identify the different ways students made use of the recordings. The same approach was adapted to the production of short, bite-sized video tutorials and worked examples. Through the Practice Transfer Adoption initiative, staff from four other universities received training from the Southampton team in the technical aspects of producing video recordings, as well as funding for a 'starter kit' comprising the key hardware required to produce high quality video resources.
Outcomes:	• Feedback from students about the availability of recorded lectures was incredibly positive, and academic staff have overcome their initial reservations about being recorded. • In the latter stages of the project, the majority of first year chemistry lectures were recorded, and the positive experiences of students indicate that the availability of the recordings genuinely helps to facilitate a smooth transition to lecture-style delivery. • Short video tutorials and worked examples were recorded to support students in carrying out self-assessment of their own work. The success of this particular initiative led to the project leader receiving the 2010 award for 'Most Effective use of Video' from the Association for Learning Technology. • Four universities adopted these practices through the PTA initiative, with each partner carrying out preliminary work in video production and dissemination to students during the timescale of the project. The resulting resources are now embedded in the taught programmes at those institutions.
Legacy:	**" The positive response from students shows that this project has had the biggest impact on the student experience of any initiative we've implemented in recent years."** [Head of Chemistry at the University of Southampton] • The recording of first year lectures in chemistry at Southampton is now seen as a standard practice. Over 800 chemistry students have benefitted so far. • Former HE STEM staff are now employed in the Centre for Innovation in Technologies and Education at Southampton, where they are working with academics across the university to promote good practice, including the production of recorded lectures and other resources.

Case Study 49: Understanding Graduate Career Progression and Motivation

Activity:	The Big Question: What Influences Career Progression for STEM Graduates
Institution(s):	Liverpool John Moores
Activity Description:	Aiming to uncover the factors that affect STEM graduate progression into STEM employment and identify good practice that positively influences choice this project brought together learning from stakeholders, HEI careers services, employers and students to develop a creative response to the careers support needs of current and future STEM graduates.
Outcomes:	• Range of practices of North West higher education institutions in STEM graduate careers advice identified and factors that influenced the level to which students engage with careers services determined. • Detailed reports on factors influencing STEM student choice from both students and STEM employers identified. • A case study of describing a set of initiatives within the School of Mathematics at the University of Manchester that have helped develop closer links with the University's Careers Service and raise awareness within our student body of careers and employability skills produced.
Legacy:	• A regional workshop to disseminate the findings brought together HEI careers advisors from the north west universities, local employers and other STEM stakeholder organisations. Participants identified that higher careers advisors did not have access to current labour market information as it relates to STEM based graduate employment in the region in an accessible format. The data sets produced are now made available to the higher education careers professionals using the STEMBUG web platform.

Case Study 50: Interactive Technologies to Support Employability

Activity:	Development of on-line Video CVs
Institution(s):	Northumbria University
Activity Description:	This pilot project supported an existing Northumbria University HE STEM funded pilot project by providing additional support to students undertaking STEM-related programmes through the development of online video CVs. Working in partnership with OVCV (onlinevideoCV) Ltd, students created an online presence to enhance potential placement and employability prospects by allowing regional STEM employers an opportunity to search and shortlist suitable candidates[72].
Outcomes:	Following recommendations made during an initial regional STEM employer meeting, the North East Process Industry Cluster (NEPIC) are developing a 'placement portal' where all regional opportunities can be collated together for use by regional STEM employers and the North East Universities. This project will continue to work in partnership with NEPIC and, where possible, will align outputs required by NEPIC.
Legacy:	**"The portal has been well received by other schools within the Institution and discussions are now underway to determine potential roll-out"** [Pro-Vice Chancellor (Region, Engagement and Partnerships), Northumbria University]

[72] http://www.northumbria.ac.uk/sd/academic/lifesciences/studsupport/online_video_pilot/?view=Standard

Case Study 51: Institutional Perspectives – Engaging Employers in Curriculum Design and Delivery

Activity:	Developing Graduate Skills Through Industry Led Touch-Points
Institution(s):	University of Lincoln
Participating Department(s)	School of Engineering
Activity Description:	The 'Touch-Points' project matched the employability skills sought by employers with opportunities to deliver these skills within a mechanical engineering degree programme. Through the project, industry-based engineers delivered teaching and learning activities within the touch-points which provided an opportunity to embed genuine industry practice throughout the entire degree syllabus.
Outcomes:	• 6 employers contributing to the delivery of 20 'touch-point' activities throughout the course of the academic year. • Wider adoption of touch-points within School of Engineering. • Development of a specific PGCE for company-based staff involved in the delivery of internal training courses. • Redesign of final year project (and extension from 3—45 credits) to include content relating to project management, and to enable projects to be sponsored by industry and involve a form of student internship. • The School of Engineering won the 2011 Lord Stafford award for Open Collaboration[73].
Legacy:	**"These touch-points have lead to a step change in practice within both the business and the University. The most immediate impact is that the School of Engineering is immediately able to accredit some of Siemens internal courses to contribute towards CATS points…these internal courses are available to Siemens customers and suppliers, so the planned accreditation or approval will give the company a distinct product offering and a commercial advantage. This win-win situation encourages further collaborations and ensures that the touch-point programme will be sustainable beyond the life of this project."** [Academic Member of Staff, University of Lincoln] • Increased student intake in Engineering to 100 for 2012 entry (up from 34 in 2010 and 50 in 2011). • Appointment of a dedicated Business Manager to mentor and assist students with application process for summer work placements.

[73] http://www.lincoln.ac.uk/news/2011/11/444.asp

Case Study 52: Engaging Employers in Curriculum Design and Delivery – The Nuclear Island

Activity:	Building the Nuclear Island
Institution(s):	Imperial College London & Cogent Sector Skills Council
Participating Department(s)	Department of Civil & Environmental Engineering and Department of Materials
Activity Description:	Nuclear Island is a nationally available, week long, hands-on new build experience for engineering undergraduates, delivering practical on site training and key behavioural traits to prepare students for working in the nuclear industry. It is underpinned by collaboration between industry and academia working in partnership to deliver and asses the learning experience.
Outcomes:	• 20 Civil Engineering students participated in the on-site activity. • A complete civil engineering programme is available for HEIs across the UK to openly participate.
Legacy:	• The University of Birmingham participated in the constructionarium for the first-time in 2011, and did so again in 2012. • A Nuclear Island learning experience for mechanical and electrical engineering students is currently being developed. • Additional funding secured by Cogent to sustain the Nuclear Island programme from April 2012 through to March 2014 through the UK Commission for Employment and Skills (UKCES) Employer Investment Fund. As part of this scheme Nuclear Island will be expanded to include learning packages for apprentices and employees[74].

[74] http://www.nuclearisland.co.uk/home/

Case Study 53: Engaging Employers in Curriculum Design and Delivery – The Grand Challenge

Activity:	The Grand Challenge Project
Institution(s):	University of Birmingham, Nottingham Trent University, Aston University
Activity Description:	Grand Challenge is a 4-week course which collaborates with engineering/science employers to provide 3rd year students with additional employability skills and experience of tackling an open-ended, undefined problem. The students work in multidisciplinary teams, applying their scientific/engineering approach to an issue which has no right/wrong answer, working through a structured problem-solving process to propose and justify their ideas, at the same time as reflecting on these experiences. Assessment is via peer review, personal submissions and the group presentation.
Outcomes:	• The Grand Challenge ran in both 2011 and 2012 at the University of Birmingham: 78 Year 3 & 4 students from a range of disciplines participated. • The Grand Challenge ran in 2012 at Nottingham Trent University: A different delivery model was utilised with workshops in term 1 plus full day sessions from 10-19 December 2012. 27 Year 2 & 3 students participated in 4 teams, - each with a postgraduate to support them. Students participated from: chemistry, physics, mathematics, forensic science, bioscience and computing courses. • Grand challenges provided by IBM and Atkins (Birmingham) and E.On (Nottingham Trent). • In a follow-on 12 month survey in 2012 students indicated they felt it had improved their skills and understanding of employer requirements. • Aston University students participated in the 2012 running of the Birmingham Grand Challenge. • Participating students have maintained their engagement with each other: 36/47 of the 2012 students actively participate in a Facebook group they established; social interactions between individuals have been maintained.
Legacy:	**"In the second year of its delivery the module participants were from both the University of Birmingham and Aston University. This was very positive…"** [Academic Member of Staff, University of Birmingham] • The Grand Challenge has now been adopted by Aston University and Nottingham Trent University: the same 4-week programme is to be developed by Aston as part of the careers and employment service provision and at Nottingham Trent within its employability skills module as a 2-week programme.

Case Study 54: Embedding Sustainable Change and Greening STEM

Activity:	Greening STEM Legacy Project – Embedding Sustainable Development
Institution(s):	University of Bradford (lead), Leeds Metropolitan University, University of York
Activity Description:	Bringing together two strategic institutional initiatives at Bradford, STEM and sustainable development, the project's focus was to promote, as well as develop awareness and increased understanding of, sustainable development within STEM subjects. This intention was realised via two primary routes: the formal curriculum and the physical STEM learning environment.
Outcomes:	The formal curriculum strand involved module development activity spanning automotive and civil engineering, computer science and chemistry. The physical learning environment aspect included a significant lab refit as a demonstrator, and substantial support of the national S-Labs Programme. Chemistry: • Green Chemistry Eco Metric project: working with chemistry staff and students to further refine the green chemistry content of UG laboratory practicals. • Big Green Lab project: a multi-stranded project to promote 'responsible science' within the chemistry curricula. The impact of environmentally-focussed interventions, including the installation of real-time energy monitoring equipment linked to a fume cupboard re-fit, as well as curriculum activities around promoting the principles of green chemistry was explored through the use of a substantially qualitative pre- and post-intervention student questionnaire. • Biorefinery project: linking final year undergraduates with the new bio refinery laboratory at the International Green Chemistry Research Centre, led by the University of York. This comprised a lecture, site visit, and opportunity to undertake a research project and propose a follow-on investigation exploring biomass to chemicals. Computing: • Software Engineering: a set of curriculum materials, digital tutorials and assessment processes were developed to increase UG student awareness of the relevance of sustainability, notably energy and carbon issues. • Low Carbon Computing: a new final year module in low carbon computing to increase awareness and understanding of the role and importance of sustainability in computing hardware, software, networks and applications. Engineering: • Low Impact Vehicle Design Competition: a preparatory project involving students to establish the framework and materials for a final year module in engineering, harnessing the research work of the Vehicle Engineering Research Centre. • Sustainable Construction Design: a project to create a repository of digital resources (film) and other educational materials on the design, build and operation of a new BREEAM outstanding Sustainable Enterprise Centre currently being built on campus. • Development of innovative web platform[75] collating resources and provides information and knowledge to support employees to broaden their knowledge of new and emerging technologies through online networks and communities and through access to shared learning resources. The platform was launched to a group of 20 construction professionals at Green Build Expo (June 2011). This has resulted in the bringing together of all information on the subject area of renewable technologies and their applications into a central community-based platform. The platform was used to launch a GV Skills feasibility toolkit in December 2012. • The Effective Laboratory: Launch of the S-Lab Conference and Awards scheme.

Legacy:	**"The challenges are especially great with regard to science, technology, engineering and mathematics (STEM) disciplines, which generally require more complex and expensive facilities than others. It is therefore gratifying that the Awards and Conference presentations have provided so many examples of innovative responses that are providing multiple benefits,"** [Sir Ian Diamond, Principal and Vice-Chancellor, University of Aberdeen] **"Auditing labs with the Green Impact/S-Lab framework has highlighted how much potential there is for environmental and financial benefit by avoiding wastage of chemicals, energy, water and other expensive resources, and from recycling and reuse."** [Green Impact Manager, NUS Services] • Lessons learned from the Big Green project and the best practice sessions at the S-lab conference and awards have been influential in the design and planning for future laboratory retro-fit at the University. Students on the bio-refinery project are continuing to develop projects and staff will continue to support and develop those activities and maintain relationships with York University. • The design competition for low impact vehicles will be held in 2013 and be further developed through the curriculum. The course materials on the design and build of the new sustainable enterprise centre will be utilised in a number of engineering modules as well as activities hosted within the new sustainable enterprise centre. • Greening STEM has involved and impacted on a number of academic and estates staff, who will continue to build and support Greening STEM at Bradford. These and other staff will continue to develop and promote Greening STEM activities through Building STEM (a new £1.2M centre for STEM education), the new £5.2 Sustainable Enterprise Centre (co-located with Building STEM and continuing the Ecoversity/STEM activities and interface that formed genesis for Greening STEM) • The S-lab conference is being held in 2013 at the University of Liverpool and the second year of the awards scheme has been announced, thereby promoting the concepts of sustainable laboratory design, practice and teaching nationally and internationally. • The original environmental technology platform has been further enhanced into an Employer Engagement Model: Technology Enhanced Knowledge Exchange Networks (working document) www.green-vision.org.uk. The legacy of the project lives on in 'Green Vision', which is now a private sector support Knowledge Exchange Network.

[75] www.gvskills.com

Case Study 55: Building Graduate Skills Through Science Communication

Activity:	Development of Science Communication module
Institution(s):	University of Birmingham, Queen Mary University of London (Adopter), Bradford (Adopter)
Activity Description:	The Schools of Chemistry and Biosciences at the University of Birmingham developed a new transferable skills module in science communication. The module was designed to provide training in both communication and key employability skills while retaining a flexible format to facilitate transfer across disciplines. The core of the module involves the students working in groups to produce videos for a general audience on subject-specific topics.
Outcomes:	• The module has been delivered as a second year 10 credit transferable skills module in the School of Chemistry at the University of Birmingham since 2010 – the current cohort size for the 2012/13 academic year is approximately 120 students. • The module is being delivered as 'Communication and Skills in Biosciences" and is being taken by all 240 students on Biological Sciences, Biochemistry and Human Biology programmes in the 2012/13 academic year. Students currently take the module as a 10 credit second year course used as core skills to develop communication and transferable skills. • The module was offered as part of the National HE STEM Practice Transfer Adoption Scheme and colleagues from Queen Mary, University of London (QMUL) (School of Electronic Engineering and Computer Science) and University of Bradford (Engineering, Design & Technology) attended two day workshops at the University of Birmingham to gain experience in delivery of the module.
Legacy:	**"All 240 students take it now as a 10 credit second year course used as core skills to develop communication and transferable skills. We are now moving to integrate it more with Careers network regarding the employment skills."** [Academic Member of Staff, University of Birmingham] **"Science Communication was delivered as 'Professional and Research Themes' to all first year students in the School of Electronic Engineering and Computer Science (EECS) at QMUL in the 2012/13 academic year. The cohort size is 240 with degree programmes ranging from BEng Electronic Engineering to BSc Information Communication Technologies."** [Academic Member of Staff, Queen Mary University of London]

Case Study 56: Meeting Employer Workforce Needs Through Distance Learning – The Hydrographic Academy

Activity:	The Hydrographic Academy: Meeting the needs of the workforce and industry through innovative, flexible, online distance learning
Institution(s):	Plymouth University
Activity Description:	The offshore survey and engineering industry workforce has limited opportunities to engage with the higher education sector due to extended deployments offshore. With high salaries and staff costs the release of personnel to study full time is seldom advantageous to the individual or the employer. For some time, there has been an unfulfilled demand for a way for the workforce to develop and enhance their qualifications, including gaining professional body recognition. The project worked closely with Fugro (the world's largest supplier of geoscience, survey and geotechnical related services) and the Royal Navy to develop and provide a learning package that could be accessed by individuals offshore. A 10-credit distance learning unit was developed and trialled with Fugro employees. This, which took into account the intermittent internet connection likely to be encountered whilst working offshore, was evaluated by both the students and their employers. Detailed feedback enabled the project team to refine the format before starting to develop the full flexible undergraduate and postgraduate distance learning programmes, which will be accredited by Plymouth University[76].
Outcomes:	• Identification of educational needs of the offshore survey and engineering industry • Teaching and learning provision regardless of the difficulties of working patterns or geographical location using evaluated online learning materials suitable for delivery via an innovative e-learning platform • Accreditation is being sought from the appropriate professional body (the International Hydrographic Organisation), who have not accredited distance/e-learning courses before. • A very positive and ongoing working partnership between Plymouth University, Fugro and the Royal Navy (FOST HM) to guide and inform further development • A transferable methodology for collaborative working between industry and academia, made available to the wider HE STEM community[77] • Over 420 potential students have registered their interest since March 2012 with 100 due to start a course over three intakes during the 2012/13 academic year
Legacy:	**"I have quite literally searched the world for an institution that offers this kind of tertiary education, and from Australia to Europe I have been unsuccessful, so thank you for your efforts! It's a huge step in the right direction!"** **"The Hydrographic Academy has given me the chance to fill a gap in my CV and develop my theoretical knowledge, whilst helping me to progress my career within the industry".** [Quotes received from students completing the first module] **"Fugro's involvement [in the Hydrographic Academy] is driven by the need not just to raise standards but to make education more accessible and broader reaching given the on-going shortage of supply of suitably qualified and experienced staff. It provides an educational and qualification route for us that is not currently available other than through full time study."** [Fugro's Global Learning and Development Manager] • Plymouth University, through its School of Marine Science and Engineering is providing funding until summer 2015 in the first instance; funding has been made available for the employment of a full time Project Manager and for additional members of staff to enable a full distance learning programme at undergraduate and postgraduate levels. • Lessons learned during the initial development of the Hydrographic Academy are being used to inform Plymouth University's future e-learning strategy. Other organisations, including the International Hydrographic Organisation, are using the Hydrographic Academy's developments as a template for future e-learning courses. • Plymouth University are working to embed discrete elements of the distance e-learning solutions developed by the Hydrographic Academy within their full time residential courses in Hydrography (MSc and BSc (Hons) programmes) by 2015.

[76] http://www.plymouth.ac.uk/hydro

[77] http://www.hestem-sw.org.uk/project?id=43

Case Study 57: Collaborative Approaches for Workforce Learning – Photonics Upskilling

Activity:	Capability Matrix for Photonics Upskilling (CAMPUS)
Institution(s):	Bangor University and the Welsh Optoelectronics Forum (in collaboration with: Aberystwyth University, Cardiff University, Glamorgan University, Glyndŵr University, and Swansea University together with Deeside College and Coleg Llandrillo)
Activity Description:	CAMPUS determined the Photonics 'Training, Research, Expertise and Equipment (TREE) ' available at all HEIs and two FE Colleges in Wales. The aim being to provide a one-stop resource to support up-skilling in the photonics industry. A strong industry perspective was brought to the project by the engagement of the Welsh Optoelectronics Forum – the de facto photonics industrial association. The project utilised the EU Photonics21 value chain headings to reflect activities in the photonics industrial sector. Photonics capabilities at the institutions were defined in relation to the 'photonics technology ' defined within the 5-volume Handbook of Optics published by McGraw Hill and sponsored by the Optical Society. CAMPUS maps expertise available within Wales into these two categories.
Outcomes:	• The CAMPUS matrix was published in hard copy and copies made available to all partners. It is also available online for employers[78]. • Two dissemination events were held (one in north Wales and one in south Wales) targeting industrial and governmental audiences; a positive response to CAMPUS was gained at both events. • Participating institutions were enabled to produce a stand-alone flyer illustrating their CAMPUS TREE capabilities.
Legacy:	• The CAMPUS collaboration forms the springboard for the development of a photonics cluster project for which funding will be sought from ASTUTE – a pan-Wales ERDF-funded project on Advanced and Sustainable Manufacturing. The proposed project on ' Optical and Photonic Instrumentation and Materials Assessment (OPTIMA) ' aims to utilise the CAMPUS-identified photonics ' TREEs' to support the development of the photonics industry. The activity offers a significant means for the HEI partners to illustrate the societal impact of their research.

[78] https://www.expertisewales.com

Case Study 58: A Regional Approach to Increasing University and Employer Engagement - STEMBUG

Activity:	HE STEM Backstop: An Online Resource to Support and Reinforce Access to HEI Services for Employers and Support Organisations
Institution(s):	Manchester Metropolitan University (lead), University of Manchester, University of Salford, University of Bolton, Liverpool Hope University, University of Liverpool, University of Chester, University of Central Lancashire, University of Lancaster, Liverpool John Moores University, Edge Hill University, and University of Cumbria
Activity Description:	The HE STEM Backstop project addressed the need to have a clear route of access into the information available to employers wanting to engage with HEIs. The project developed, STEM Business University Gateway (STEMBUG)[79], a web-based resource containing easily navigable information from multiple partners and sources. A prominent feature is the enhancement of the DiscoverHE™ resource developed through the Higher Level Skills Partnership[80], whereby CPD of relevance to STEM disciplines/industries is available in an enhanced form.
Outcomes:	• Central portal for accessing information on north west higher education institution STEM CPD provision as well as placements, internships, knowledge transfer partnerships (KTPs), higher apprenticeships, recruitment contacts and a large database of HEI expertise (research capacity, facilities etc.) across STEM. • STEMBUG provides up-to-date details of those key contacts within HEIs across the North West.
Legacy:	Manchester Metropolitan University has committed further resources to the on-going development of the STEMBUG website and database which includes: optimisation of functionality (user experience); production of a 'user guide' to allow individual institutions to update their own content; and, analysis of the usage pattern using analytics tools and make recommendations for further improvements. In addition to employers being able to identify specific provision, the development and embedding of a capability matrix[81] will provide business and industry with a quick and easy way of identifying which north west university has the relevant expertise to meet their skills needs. The capability matrix mapping model was extended to the Photonics industry in Wales (Case Study 57).

[79] www.stembug.co.uk

[80] Winner of the 2010 Times Higher Award for 'Outstanding Employer Engagement Initiative'

[81] http://www.stembug.co.uk/Capability/Expertise

Case Study 59: A Regional Approach to Meeting Employer Needs Through Professional Development Opportunities

Activity:	Meeting Industry Needs for a Highly Skilled Workforce in Science, Technology, Engineering and Maths
Institution(s):	North West Universities Association (lead), Manchester Metropolitan University (with Wigan and Leigh College, Liverpool Community College, South Cheshire College), University of Central Lancashire, University of Salford, and Liverpool Hope University
Activity Description:	At higher levels, employers across the STEM industries report a wide range of skills gaps in their existing workforce. This project addressed some of these gaps through the development of a range of regionally co-ordinated CPD modules at HE Level 4+ aimed at those already in work with no previous experience of HE.
Outcomes:	• A skills gap analysis of regional STEM industry needs at Level 4+ undertaken with contributions from Sector Skills Councils and other stakeholder organisations in the north west. • A suite of 26 modules (ranging from 5-20 credits) produced across 4 north west higher education providers which address the needs of a wide range of STEM sectors including the aerospace, automotive, engineering, energy, textiles and construction sectors. This includes a free CPD module delivered collaboratively by 3 universities[82]. • The strong partnerships established have resulted in Sector Skills Councils, Regional Cluster Organisations and Professional Bodies marketing the new provision to their employer networks and raising its profile in addition to institution's own marketing strategies. • An effective mapping model for the identification of workforce development needs and case studies for employers[83].
Legacy:	**"At MMU, the provision is being built into the Open Professional Programme at Hollings allowing greater sustainability and a wide choice of additional modules for learners."** [Academic Member of Staff, Manchester Metropolitan University] • The priorities mapping document[84] has been made available to all north west higher education institutions and has resulted in some universities (Liverpool and Liverpool John Moores) using it to inform their own provision planning. • Availability of a range of bite-size CPD modules, developed in response to industry needs, to enable the development of a highly and appropriately skilled STEM workforce[85].

[82] http://www.northwesthestem.co.uk

[83] http://www.nwua.ac.uk/STEM/STEM_Case_Studies/Course%20brochure%20AW%20(Case%20Study).pdf

[84] http://www.nwua.ac.uk/NewsAndEvents/News/Docs/NW%20STEM%20CPD%20PRIORITIES.pdf

[85] http://www.nwua.ac.uk/STEM/STEM_Case_Studies/Course%20brochure%20AW%20(Marketing).pdf

Case Study 60: Developing New Provision Through Partnership and Collaboration – Engineering Gateways

Activity:	Engineering Gateways Practice Transfer Partnership
Institution(s):	Engineering Council (Lead), Aston University, Coventry University, University of Derby, University of Greenwich, University of Hertfordshire, Leeds Metropolitan University, Kingston University, Northumbria University, University of Staffordshire, and University of the West of England
Activity Description:	In 2006 the Engineering Council developed a framework for flexible innovative HE provision for engineering employees, leading towards engineering professional qualification (IEng or CEng). By 2011, five universities were delivering these integrated programmes, two at Bachelors level, 5 at Masters level, and over 70 work-based students were enrolled, but the Engineering Council was aware that a range of other higher education institutions were interested in developing such degrees, but sometimes barriers to implementation were cited as the reason for not progressing to the design and delivery stage. The Practice Transfer Partnership provided an opportunity for a project to overcome these barriers by drawing draw upon and transfer the range of experience, successful practice and differing models of delivery, enabling other HEIs to offer such degrees at Masters or Bachelors levels.
Outcomes:	• 5 universities shared their experience and practice with 5 universities seeking to adopt the Engineering Gateways model. • Development of a toolkit to support universities wishing to adopt the Engineering Gateways model[86]. • Professional engineering courses developed, and currently recruiting students at the Universities of Derby[87], Greenwich[88], and the West of England[89]. • The Universities of Coventry (MSc Professional Engineering (Building Services Engineering)) and Leeds Metropolitan (MSc Building Services Engineering) are in the advanced stages of work to implement professional engineering programmes in the coming academic years.
Legacy:	**"All five universities are either already marketing, or will be marketing, an Engineering Gateways type of degree. This brings to twelve the number of providers of Engineering gateways type degrees, which increases the size of the community of practice…Two of the new providers are offering a discipline hitherto not available (building services engineering) to the workforce and for which there is a perceived need."** [Engineering Council Representative] **"This project started out to simply add in a new MSc to the Department's portfolio. Unexpectedly, it has offered the opportunity to completely rethink our Postgraduate provision in Engineering. In addition, although we have not been able to start all the paperwork yet, it has informed us on how to deal with potential WBL provision at the Undergraduate level, which was definitely one of the key objectives of the project."** [Academic Member of Staff, University of the West of England]

[86] http://gatewaystoolkit.engc.org.uk

[87] http://www.derby.ac.uk/professional-engineering-msc

[88] http://www2.gre.ac.uk/study/courses/pg/enggen/profeng

[89] http://courses.uwe.ac.uk/h30b12/

Case Study 61: Institutional Perspectives – Creating Part Time Learning Opportunities in STEM

Activity:	Embedding Resources for Distance Learning
Institution(s):	University of Hull
Participating Department(s)	Department of Chemistry
Activity Description:	The University of Hull had been offering a part-time Foundation Degree in Chemical Sciences by day-release for several years, but it became apparent that employers were finding it ever more difficult to release employees to travel to the University for one day per week. In response to employers' needs the Foundation Degree was redeveloped for distance learning, thus providing a more flexible route for prospective students studying anywhere. Completion of the three year Foundation Degree enables students to progress onto the part-time BSc in Chemistry, which can be completed in a further two years.
Outcomes:	• 120 credits of learning developed in the first year, the online course presence and some of this material was developed explicitly as part of the National HE STEM Programme project. This has added to the course portfolio of the departments and engaged five academics in authoring distance learning materials. • The course has raised the profile of the university beyond the immediate Humber region and has enabled engagement with a wider range of employers. • Previous to this development recruitment onto the day-release version of this course was dropping (7 in 2008/9, 3 in 2009/10). The re-launch of the course in September 2010 attracted 13 students; over 30 students are now participating in the Foundation Degree.
Legacy:	**Staff are now committed to the activity and will continue to develop it".** [Academic member of staff, University of Hull] • An extension of the project has developed a further 120 credits of material to enable the 'top-up' to BSc level to be accessible via distance learning. • A distance learning foundation stage (for those without A level Chemistry) is now available[90].

[90] www.hull.ac.uk/ICI/

Case Study 62: Meeting Employer Workforce Needs – Fast-track and Escalator Provision

Activity:	A Fast Track Part-time Level 4 Pathway for Workforce Enhancement in the Manufacturing Sector and Part-time Provision to Support the Metals Industry in Wales (the Steel Academy)
Institution(s):	Swansea Metropolitan University, Glyndŵr University
Activity Description:	In partnership with Glyndŵr University, Swansea Metropolitan University developed an intensive fast-track programme of study, comprising 60 credits in mathematics and engineering science at Level 4. This programme was delivered on Friday afternoons and evenings, to minimize time out of work for the students, over an extended academic year (42 weeks). Recognition of prior learning and experience provided exemption from Level 4 modules in manufacturing technology and engineering applications, and as such allowed fast track progression for employees who possessed appropriate experience but who otherwise lacked the qualifications necessary to permit them entry to the part-time degree programme. Students who successfully completed the programme were able to enter the BEng degrees at Level 5 alongside the usual HNC-qualified students. Working with Tata Steel and other companies, Swansea Metropolitan University also designed, developed and piloted a part-time programme in Materials Engineering, with specialist options in steel, non-ferrous alloys, welding, non-destructive testing, polymers and composites. The programme consists of an integrated HNC/Foundation Degree/BEng (Hons), providing students with a variety of entry and exit points. Delivery was aligned with the successful model of the other part-time BEng programmes in the School of Logistics & Manufacturing Engineering and took place on Friday afternoons and evenings over an extended academic year.
Outcomes:	• A pilot group successfully completed the fast-track level programme who would have previously been unable to enter part-time degree programmes in engineering. Students have progressed to Level 5 and appear to be doing well; there appears no difference in their performance from the more highly qualified students who were admitted directly to Level 5. • An integrated part-time BEng/FD/HNC programme in Materials Engineering developed and an initial cohort of students recruited. • A dedicated on-line resource established with University-developed learning materials and links to other on-line resources. • Closer working relationships established with employers, industrial fora and SEMTA. • Faculty staff found that they had to reflect on their approach to pedagogy and developed a renewed interest in engineering education. • A good working relationship developed with the materials discipline at Swansea University, laying the foundation for further collaboration.
Legacy:	**"In addition to the development of the academic programme, there were other unexpected spin-off activities. Two companies felt that they were not yet ready for a degree programme, but needed some specific higher level training. As a result two Level 4 training programmes were developed to meet these needs. These were highly successful and the programmes were extended to cover a much wider range of employees than had originally been intended."** [Academic Member of Staff, Swansea Metropolitan University] **"In addition, SMU has developed a partnership with an English FE college, with a view to delivering a similar integrated undergraduate programme with a bias towards polymers and composites to address needs in another industrial sector. A partnership has also been developed with a Welsh FE college to develop work based learning activities and a HNC in Welding Engineering."** [Academic Member of Staff, Swansea Metropolitan University] • A further cohort recruited to the BEng programme in Materials Engineering in 2012/13 and Tata Steel are recruiting students with good A-levels specifically for entry to this programme and employment as technical trainees. • The fast-track programme has been fully incorporated into the part-time BEng portfolio, and a cohort of Level 4 students was recruited again in the 2012/13 academic year.

Case Study 63: Meeting Employer Workforce Needs – Gearing up for Industrial Growth

Activity:	Gearing up for Industrial Growth
Institution(s):	University of Wolverhampton
Activity Description:	Following a major consultation with industry, a totally new manufacturing degree (BEng) has been developed which includes the latest industry supplier chain courses (SC21), simulated working environments, manufacturing processes (including laser sintering), and business and management systems. The degree is offered via an entirely new mode of delivery whereby learners based in industry undertake work based learning, with the ability to stop-start study as required, over 45 weeks per year (accelerated) to achieve the full degree within two-years.
Outcomes:	• Degree programme is validated and recruiting from industry for first running in September 2013. • Feeder routes from the Black Country University Technical College (including a bridging programme for those without pre-requisites) have been established. • Flexible delivery enables opportunities for continuing professional development and lifelong learning to be provided to those within the workplace with a co-delivery option for the employers. • An alternative career route to graduate engineer that is attractive to students. Fees paid by industry, with possible future Skills Funding Agency partial funding, rather than a traditional student loan.
Legacy:	**"…you should be commended on this innovative development, and this Manufacturing Degree should be a flagship course for the University."** [Programme External Examiner] **"We have recently been successful in a grant application with the Black Country Consortium for a £2M project called 'The Skills Factory for High Value Manufacturing' through the UKCES Growth Innovation Fund. This project will support local companies access the right training and develop significant numbers of highly skilled people from local communities required to support the growth of these local companies, preventing the migration to low cost economies."** [Academic Member of Staff, University of Wolverhampton] • Significant institutional change to staff practices, academic regulations, information systems & management and lessons learned (particularly relating to delays and how to overcome them).

The National HE STEM Programme

The National Higher Education Science, Technology, Engineering and Mathematics (HE STEM) Programme was a three-year initiative funded by the Higher Education Funding Councils for England and Wales through an activity grant to the University of Birmingham in August 2009. The Programme co-ordinated its activities through six geographical regions represented by the Universities of Bath, Birmingham, Bradford Manchester Metropolitan, Southampton and Swansea, and by working in collaboration with four Professional Body Partners: The Institute of Mathematics and its Applications, The Institute of Physics, The Royal Academy of Engineering, and the Royal Society of Chemistry.

Working across the higher education sector in England and Wales, with a particular focus upon the disciplines of Chemistry, Engineering, Mathematics and Physics, the Programme supported higher education institutions in encouraging the exploration of new approaches to recruiting students and delivering programmes of study. It enabled the transfer of best practice across the higher education STEM sector, facilitated its wider adoption, and encouraged innovation. Through collaboration and shared working, the Programme focused upon sustainable activities to achieve longer-term impact within the higher education sector.

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