Sharing effective practice through collaboration

– Case Studies arising from the National HE STEM Programme Collaborative Projects Initiative

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Introduction

In August 2009, the National HE STEM Programme commenced its three-year period of operation within the higher education Science, Technology, Engineering, and Mathematics (STEM) sector but with a particular focus upon the disciplines of Chemistry, Engineering, Mathematics and Physics. Within its proposal to the Higher Education Funding Councils for England and Wales, the Programme defined an ambitious three-year portfolio of activity based around a number of fundamental, and underpinning, principles. In particular it sought to build upon the work of the four disciplinary pilot projects led by the Royal Academy of Engineering (the London Engineering Project), the Institute of Physics (Stimulating Physics), the Royal Society of Chemistry (Chemistry for our Future), and the Maths, Stats & OR Network on behalf of a consortium of mathematical bodies (More Maths Grads). Additionally the Programme aimed to identify and build upon proven practice within the higher education sector, and to develop collaborative activities, both between universities, and between universities and other STEM sector organisations.

In early winter 2009, the Programme initiated its first open funding call for one-year projects that were based around these principles. 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. It is these successful projects that form the case studies included within this publication.

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. A key feature of all successful proposals, and indeed an important factor within the decision making process of the reviewing panel, was a commitment to the longer-term continuation of the activity post-funding period. This forms another underpinning principle of the Programme, ensuring all activities initiated have longer-term potential for sustainability and are not entirely reliant upon further sources of external funding. This was scrutinised through an explicit section on the application form and a supporting statement from a senior colleague within the institution. The approach of the Programme to sustainability has been to enable activities to become naturally embedded within the core practices of the host institution; this might have been through, for example, curriculum change, demonstrating increased efficiency or effectiveness over a previous approach, influencing or informing departmental approaches and activities, or enhancing the skills and knowledge base of higher education staff in delivering or supporting the activity. The sustainability of the 20 projects initiated, and indeed their legacy, is particularly evident within the case studies that follow.

Legacy of the Collaborative Project Initiative

The individual case studies form an output from each project and are based upon a standard layout and format; they were compiled approximately 20 months after the start of the project initiative. A degree of flexibility was allowed in terms of completion date as the nature of the activities undertaken was sufficiently varied that a standardised timescale proved be inappropriate; additionally, some extensions to project timeframes were granted.

There is a visible legacy of the outcomes from each project, and this has become increasingly evident since their formal completion. In the majority of cases activities continue within the departments who participated within the initiative, including instances where these have been extended or developed further; some have also been transferred more widely to other institutions through the National HE STEM Programme. In the small number of cases where the activity hasn't 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 Lancashire STEM Symposium have been adapted for use in school visits and events.

Given that a period of time has passed since the production of the individual case studies and the production of this publication, it is timely to explore the additional legacy that has emerged for a number of projects beyond that described within the cases studies themselves.

At the **University of Hull**, over 30 students are now participating by distance learning in the foundation degree in chemical science that was developed. Currently the 'top-up' to BSc level is only available through day release, but following the success of this development, the University is now in the final stages of working with the National HE STEM Programme to develop a further 120 credits of material to enable this by distance learning. At **Aberystwyth University** and the **University of Nottingham**, the activities established have been explicitly referenced within their Fee Plan and Office For Fair Access (OFFA) Access Agreements as an example of the commitment of both universities to widening access and participation. Additionally at **Nottingham**, the intervention developed has been adopted by the University of Exeter through the National HE STEM Programme 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.

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; **Loughborough** with the Universities of Birmingham, Bradford, Cumbria, Exeter, Salford, Staffordshire, and the West of England; and, **Newcastle** with the Universities of Bradford and Kingston. This demonstrates the value of the initial activities undertaken through this initiative, as judged by those within the higher education sector, and provides further evidence of the Programme's commitment to transferring learning and effective practice. 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, and in a further activity directly related to this initial project, Newcastle is currently working to make high quality diagnostic tests in mathematics nationally available in response to a demand identified by the National HE STEM Programme.

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

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** collaborated closely to ensure their work complemented, rather than duplicated, each other's efforts.

The learning generated from overseeing all 20 collaborative projects also 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 financial support and access to expertise to help implement these. This was specifically commented upon with the *Evaluation of HEFCE's Programme of Support for Strategically Important and Vulnerable Subjects (2011)*[1]:

> ***"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."***

Further initiatives were established to share and transfer effective practice more widely across the higher education STEM sector in the later stages of the Programme. Two practice transfer initiatives were

[1]Retrieved from http://www.hefce.ac.uk/pubs/rdreports/2011/rd05_11/rd05_11.pdf

launched in 2011, the first offered higher education institutions with effective, and in particular evidence based practice, the opportunity to share this with others; this resulted in six strategic partnerships being established in key activity areas (outreach and strategic regional working with schools and colleges; diversity; retention; careers; work-based learning; and, university technical colleges (UTCs)). The second took a unique approach to disseminating the work of National HE STEM Programme initiated projects by allowing other universities who had not previously participated in the activity to directly 'adopt' the intervention for themselves. The Programme provided financial support to the 'adopting' 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 almost 80 examples of effective practice being transferred across the sector.

There is evidence that the approach of the Programme in designing activities around collaboration is being adopted by other organisations. 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. The Higher Education Academy is currently scheduled to continue the scheme through a further open call for projects in January 2013.

Learning, Findings and Key Messages Emerging from the Collaborative Project Initiative

The 20 collaborative projects represent a significant body of work within the higher education sector, and much learning has emerged that offers helpful insight to others wishing to undertake similar activities in the future. The key messages emerging are summarised by theme below with cross-referencing to the individual case studies by the lead author [surname] where further information is available.

Student engagement

Student engagement forms a key theme throughout many of the projects. In all projects, students are the ultimate beneficiaries of the intervention, and this is to be naturally expected, however in many others instances they are direct contributors helping to establish the activity, develop resources [Lowe, Overton], deliver the intervention [Abrahams, Darragh, Hibberd, Hooper], evaluate it [Driscoll], or even lead their own projects [Lamb]. Such involvement not only benefits the student in terms of financial reward, for example a paid summer internship, but also in terms of the wider skills they can develop for employability. Additionally, if students are asked to develop learning materials for use by others, it can help improve their own understanding of the topic much more deeply.

Once an activity has been established, there can be a challenge encouraging students to engage with the materials, approaches [Hibberd], or resources developed [Driscoll], despite other students finding them beneficial. Members of university staff have a role in championing and promoting the activity to students, but it is equally important to ensure the positive feedback of students is communicated to other members of the cohort. An approach to consider is utilising students who have engaged as ambassadors to promote the intervention to their peers, much in the way [Abrahams] utilised students to champion and engage others in their discipline.

Provision of Outreach Interventions

Delivering successful outreach interventions can pose a number of challenges for many universities. Several projects [Croft, Moss, Williams] noted an increasing difficulty in attracting students from schools and colleges to attend off-site events which may be in part due to the 'rarely cover' policy that has been implemented in schools within recent times; this seems to affect secondary schools more than primary schools. Additionally, financial resource constraints mean schools can find it difficult to travel to off-site events [Darragh]. An alternative approach is to take outreach activities into schools, but this has both time and cost implications for the university delivering the activity, particularly if multiple ambassadors are involved; the time implications are significant as a one-hour activity can take an entire morning or afternoon, particularly for schools in rural areas.

The collaborative projects identified a number of approaches to address these issues. Offering a consolidated day of activities, either within the university [Moss, Williams] or school [Hooper] aids scheduling for teachers, but also enables students to see how the different STEM subjects relate to each other rather than seeing them in isolation. Utilising a more centralised, but local venue for the target schools such as a sixth-form college [Darragh] or museum as a hub to which students attend, can provide additional benefits such as essential administrative support to the activity. Another approach is to take interactive outreach activities to public events and places [Abrahams, Croft, Ryan] where there will potentially be a large number of participants, both students and their parents, or to provide access to specialist equipment that teachers cannot readily access [Ryan].

Repeat outreach interventions are known to be beneficial in maintaining student interest even if they don't radically change their future study plans [Williams], and have real value as a means of consolidating more expensive outreach activities such as summer schools. A natural challenge is that such a focus reduces the potential 'pool' of available students who might be recruited to the activity, which is also a challenge in general [Hooper, Moss, Williams], but recruitment issues can be in part addressed by engaging others to assist, for example the Local Education Authority [Hooper], an outreach management service [Williams], or the outreach office within a university

As well as offering direct benefit to school and college students, outreach events can help contribute to the professional development or confidence of teachers through engaging them in direct dialogue during the planning stages of an activity [Croft], through the provision of equipment, instructions and inspiration for both open-ended and closed activities [Ryan], or through how-to videos and guides that might have students as their primary audience [McOwan]. The professional development of those delivering the outreach activity is equally important, not just initial training [Croft], but ongoing mentoring and opportunities for them to develop and hone their skills [Abrahams]. Not all deliverers are equally suited to each type of outreach activity, and so outreach leads need to be chosen carefully, but the time spent training and supporting these individuals is amply rewarded, both in terms of the quality of the provision they offer, and what they themselves gain in terms of transferable skills [Duncombe].

Collaboration and Networking

As is to be expected given the nature of the call, collaboration and networking formed a key component of all projects, and their benefits were well documented by many of them. They offer the opportunity to learn from the experience and ideas of others through the sharing of knowledge [Driscoll, Goodhew, Lowe], by observation [Hooper, Moss], or as a forum for the development of ideas. A particularly innovative approach was implemented by [Moss] which linked the delivery of outreach activity with staff training and development days. Collaboration allows a regional approach to training and delivery which can offer economies of scale and increased reach [Duncombe], and access to particular areas of expertise that might otherwise not be available [Hibberd].

Collaboration can often lead to the establishment of a network, a group of like-minded individuals with similar interests, working together and sharing information and ideas to achieve common goals; this is especially true where there is a common issue requiring attention [Foster]. This can act as a stimulus for encouraging additional participation and engagement in an activity by those who might otherwise have only been peripherally involved [Driscoll, McOwan]; there are benefits too for personal and professional development which might be further realised through mentoring [McOwan]. Networking opportunities facilitated within an institution, for example a seminar organised across a department or faculty to discuss learning and findings, can lead to further buy-in and engagement with the activity [Croft].

A network can help in developing relationships that aid the planning, communication and co-ordination of events [Moss], especially by engaging those working within schools and colleges in the build-up to the outreach activity [Croft], and by enabling integration with other networks and organisations. A network approach also helps ensure that the links between schools engaged in university-led widening participation activities are not solely dependent upon a single institution, but are sustainable and strengthened through a collaborative or coherent [Williams] approach to the delivery of outreach sessions, and allows schools to work with the university that is most appropriate to the activity they wish to run [Duncombe].

Naturally challenges can exist with a collaborative or network-led approach to an activity. If the activity is led by a single individual on behalf of the network, progress can become constrained or delayed if either the circumstances of the individual or their institution change [Duncombe], and co-ordination and communication between large teams can sometimes be difficult [Darragh]. Similarly, while involving other organisations, such as employers, in the early stages of the development of a resource can add valuable expertise and be a good way of developing wider relationships [Easson], it may not always yield a clear way forward and the importance of trusting one's professional instinct remains vital [Ryan]. Additionally, writing learning materials and resources in a uniform manner as a larger team takes considerable planning and effort [Sangwin].

Developing Infrastructure

Several projects utilised the bulk of their allocated funding to establish the necessary e-infrastructures needed for their activity. [Goodhew] developed a bespoke online delivery tool for the questionnaire as existing systems were unable to offer the required flexibility, and [Irvine] invested significant effort in incorporating an automated approach to assessment within the virtual learning environment. While this requires significant up-front time and financial resource investment, once such systems are embedded and functioning optimally, their longer-term potential for sustainability increases. A similar case can be made for the development of other resources and materials which can often either be used directly in a teaching context, or as a standalone resource [Driscoll, Easson, Lowe].

Careful planning is required when implementing online systems that are to be directly used by students as part of core teaching to ensure this does not impact negatively upon the quality of teaching or the student experience; significant user and reliability testing is also required prior to a launch with students [Irvine].

Institutional buy-in

An institutional contribution has undoubtedly been a critical factor to the success of all activities undertaken as part of this initiative. The host universities each demonstrated senior-level support at proposal stage and a financial contribution which may have been in-kind.

Ongoing support has also been critical. Support from senior colleagues during the delivery phase can help prioritise the activity for all involved [Overton], the leverage of additional funds from within the institution can bring further benefits [Easson, McOwan], as can support from centralised units or departments not initially detailed in the proposal, particularly through the provision of technical expertise or equipment [Driscoll, Lowe]. A contribution in kind for the use of facilities, for example for meeting and events, was evident in all proposals, but was particularly essential for those that involved collaboration and networks [Abrahams, Duncombe, Foster, Goodhew].

Part-time learning

Part-time learning did not feature significantly within the initial 78 applications for support, and consequently only one project focused upon this National HE STEM priority. This reflects the initial expectation of the Programme Team that its activities in this area would take longer to establish, and has proved to be the case. Many universities cite lack of demand amongst employers and individuals as a reason for not providing non-standard study modes, either for part-time learners or those within the workforce. The learning from this one project [Overton] clearly demonstrates that with the right course content, delivery mode, and subsequent quality of experience for participating students, there is a real appetite amongst learners for such provision; this, to a somewhat limited extent, validates some of the many labour market projections currently available.

Conclusions

The approach of the national HE STEM Programme within this initiative of instigating collaborative activity across the higher education STEM sector has proved particularly successful. A typical funding allocation of around £10,000 per project might imply an expectation of very localised, or indeed narrow, outcomes, yet there is evidence of projects having a much wider influence. Not only have projects met their own initial expectations, they have often exceeded them with activities having a far wider impact and legacy than initially envisaged. The approach of building upon effective practice through collaboration shows just what can be achieved with a relatively modest level of financial resource, however, a critical factor in yielding success is a genuine appetite, need or rationale for implementing an intervention which should be explicitly, and carefully, scrutinised at the outset.

Such interventions are often the starting point in a longer-term development or vision, and in many cases the intent to establish the activity was already present. The Programme itself provided the opportunity, stimulus, support and recognition to enable project leads to take the activity forward. On this note it would be wrong to conclude without mentioning the immense commitment and dedication of all those involved in leading and supporting the project activities to their conclusion. Human effort is often overlooked when analysing projects, but project leads typically provided their time without financial recompense, and many others became involved, often through goodwill, during the development and delivery phases helping the projects overcome any challenges they have reported.

Many of the case studies highlight additional resources that have been produced as outputs from the individual projects; these can be accessed by visiting: **www.hestem.ac.uk/cptf**

Michael Grove,

Director – National HE STEM Programme

September 2012

Case Studies: Widening Participation Through Strategic Working With Schools, Colleges and the Local Community

Maths busking: Engaging the general public and school groups through the powerful medium of street entertainment

Project Lead: David Abrahams, School of Mathematics, University of Manchester and Sara Santos, The Royal Institution of Great Britain

Collaborating institutions: Royal Institution; University of Bath; University of Coventry

Abstract

Busking is a form of performance art that captures its audience from otherwise indifferent members of the public. As such, buskers have developed a range of approaches to draw in crowds. Maths Busking takes a unique approach to public awareness of mathematics. Maths Busking focuses on the performance of the subject, yet gives equal importance to the mathematics.

The primary focus of Maths Busking was to develop engaging and innately entertaining mathematics routines that can capture an audience irrespective of their mathematical background. The primary aim of this current project was to use the proven intervention of Maths Busking to develop a broad network of trained buskers with experience of hands-on events. The project would also include developing two performance kits and a tutorial pack for others to use to reproduce the activities for themselves as well as a website containing follow-up resources for the public and a video which could be used for dissemination, promotion and training.

Background and Rationale

Mathematics is often perceived as a dull, uninteresting and unpopular subject. Many existing initiatives aim to improve the public image of mathematics in schools, through teaching and in the media[1]. However, the majority of the population is not 'reached' by books, mathematics lectures and programmes on Radio4 or BBC4. Mathematicians often share 'chestnuts' of surprising and beautiful mathematics at professional gatherings. So it is proposed that there must be a way of appreciating the beauty of mathematics and its relationship to the physical world without the need for serious study in maths.

Buskers meet the same disinterested public with whom mathematicians are familiar. Thus, the primary focus of Maths Busking is to develop engaging mathematics routines that capture the audience whatever their mathematical background. The mathematical level required by the audience is only curiosity and basic numeracy. Several of the activities focus on how mathematics is vital to people's lives and how it underpins other STEM areas.

Heavy emphasis is placed on training buskers so they can continue to interact with the public after the initial events. Mathematics is under-represented in science fairs and festivals[2]. Busking is an excellent means to communicate and the training is a creative way of developing communication skills transferable to areas such as teaching and lecturing.

This project matches many of the aims of the National HE STEM Programme. Busking reaches a diverse set of people; encouraging young people, inspiring those interested in lifelong learning and assisting with the general mathematical literacy of the public.

Implementation

With few mathematicians known to be performers outside the maths circle[3] the project recruited and trained individuals to perform at a variety of events from school groups at science fairs, to the streets of London alongside professional street performers. In total, more than 150 people signed up for 12 training

[1]For example, Carol Vordeman's math on BBC1's "The One Show'

[2]This opinion comes from informal consultation with the mathematics promotion community, including the Maths Prom list

[3]For an exception, see: Arthur Benjamin's biography, http://www.ted.com/speakers/arthur_benjamin.html and the **Technology, Entertainment, Design (TED) website http://www.ted.com/ for more details and videos**

sessions from March 2010 to date, and there were a total of 41 Maths Busking performance days.

The training sessions were popular amongst teachers[4], science communicators and STEM Ambassadors, and for researchers in mathematics and sciences. The UK and overseas media has brought the project to a wide audience of all ages.

Training was innovative, helping trainees to communicate mathematics in imaginative ways, to fully define and understand the fundamental criteria of what makes good busking and to critique new performances and ideas. Another important characteristic of Maths Busking is that the mathematics is not explained; if explanations are given they come from the audience[5].

Evaluation

The Maths Busking events were evaluated by questionnaires developed and analysed by Dr Margarida Sardo, researcher at the Science Communication unit at the University of West of England. The training sessions were evaluated using the Generic Learning Outcomes criteria that are widely accepted in the community and any changes made accordingly. The shows themselves are judged against the pre-defined criteria before becoming part of any performance repertoire.

To guarantee standards, and provide a safe and enjoyable environment for the Team and the public, the performing team is always led by an experienced busker, allowing newly trained buskers to start as helpers and to learn by watching others.

Feedback from the audience during delivery is limited, given the nature of the performance. To maximise feedback visits to the Maths Busking website, emails from the public, on-site questionnaires, and snapshot interviews are all taken into account.

Anticipated barriers included the difficulty of finding suitable performers. Organising training days was also not straightforward. Teachers have difficulty taking time off work but weekend sessions are logistically more difficult to arrange and often more costly to run. For example, university buildings were used as the training venues, which are not normally open on weekends unless a dedicated porter is employed. Although the performing teams have improved considerably with experience and feedback, it is clear that, to progress, performers need to continue to hone their performance skills[6].

[4]The training days were particularly popular with teachers seeking new ideas on how to engage disaffected pupils and to offer varied learning styles

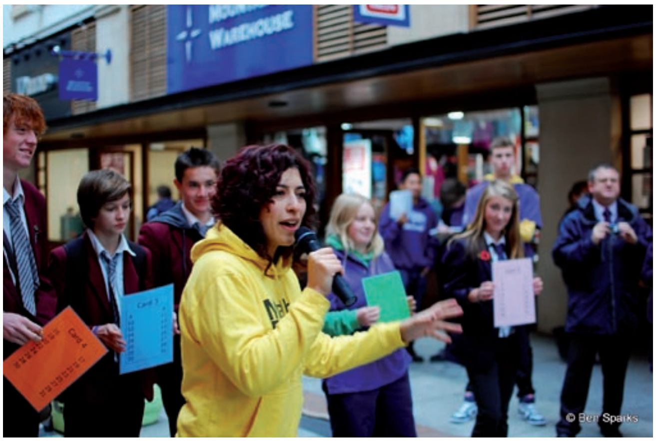
[5]The team refers people to the website http://mathsbusking.com for further information

[6]One suggestion is to hire a performance trainer, although to date a lack of funding has prevented this from taking place. In addition, an advanced training course for experienced Maths Buskers is desirable

Since March 2010 the project and the Team have been directed by Sara Santos from The Royal Institution[7]. The project has proved a burden without recourse to paid administrative support. Recently, events have been supported by an administrative assistant, at the expense of the person booking the event. Some requests for events were not met due to a lack of organisational resources.

The project was started by Sara Santos and Matt Parker from The Royal Institution[8] and Steve Humble[9]. With funding from The Institute of Mathematics and its Applications (IMA) and The London Mathematical Society (LMS), the three piloted a training session and defined the criteria for a good Maths Busking event. Professor David Abrahams at the University of Manchester oversaw and supported the project, obtained funding and assisted in attracting supporters to the events. The contribution in kind of venue and facilities to run training days was also invaluable[10]. The feedback from staff at the first training days allowed us to improve subsequent sessions.

A large number of people at a variety of institutions have enabled Maths Busking performances to take place[11]. The IMA and the LMS were key by initially investing in the project and allowing the first training day and performances to run.



The media features produced by BBC radio 4's "More or Less", BBC Online, the journalist Harriet Swain, the Guardian, and National Public Radio in the US, generated a wave of interest from teachers and other educators in

[7]For information, see: http://bit.ly/am1fka

[8]For more details, please see: http://www.rigb.org/showContent/00000002557 and http://standupmaths.com/

[9]For more details, please see: http://www.mathscareers.org.uk/viewItem.cfm?cit_id=382794

[10]The Project Team thanks the universities of Manchester, Greenwich, Bath, Aston and Leeds for making their buildings available for the training days. Special thanks to Professor Chris Budd for opening the building at Bath and supporting the training team. Both Greenwich and Manchester have covered catering costs for one training day each. Recently, The National HE STEM Programme funded another training day in Leeds in preparation for the Leeds Science Festival and the British Science Festival in Bradford

[11]The Project Team are grateful to a large number of people who have assisted in making the Maths Busking project such a success.

the UK and abroad. Video producer, Moncho Aldamiz, was extremely helpful and his goodwill allowed a promotional video to appear on the Education Guardian website at the same time as the article in the newspaper.

Discussion

The Maths Busking project has been very successful and has generated significant media interest. The project continues to attract attention and has gained momentum to continue. The Project Team is currently seeking financial support and partnerships in order to sustain an administrative structure.

Initially, more than 150 people registered to train for Maths Busking over 11 training days. As a direct result, 25 performers delivered a total of 34 performance days. Further to the planned events, requests to perform in Nottingham and Plymouth, and at the Museum of Science and Industry in Manchester were received. The Portsmouth performance was followed by a masterclass on the mathematics behind the Maths Busking shows. Additional training events were also held; one public training day and performance in Leeds and two private training sessions for teachers, primary teacher assistants, and adult numeracy trainers. Queen Mary, University of London also ran a training taster for its students, and a few pupils from a school in Hackney received training so they could perform at a school fundraising dinner.

Sustainability

The project's website was set up to provide mathematical follow-up to the shows. After a performance, visits to the website focus on answers to some of the show's questions, whereas after a media mention, visits to the site focus on contact information or general information on Maths Busking.

Maths Busking is attracting more people into communicating mathematics. A key aspect is that Maths Busking has a 'cool' element about it. Although the programme attracts people who want to perform, being part of the Team offers an initiation into the world of maths communication. Many ideas for maths busking shows, which were trialled at the training sessions, turned out be to unsuitable for performances but proved excellent for other forms of communication such as workshops and classes.

Following requests from teachers and feedback from buskers the Project Team intends to look into more shows dedicated to primary school children. One possible source of income for the project is the running of professional development for primary practitioners: on the one hand taking some ideas that can be used in the classroom, on the other hand contributing to the mathematics engagement and enrichment of the teachers themselves. Many teachers in primary schools feel they have poor levels of confidence and competence in mathematics. Maths Busking could aid the delivery of high quality and captivating mathematics.

- Overall the project has been an extremely rewarding experience for all involved. For the mathematics community this project has proven to be a new mechanism of outreach. The full impact of Maths Busking on young people will be known in time, but feedback received from performances so far has been very positive.

With regards to sustainability, the volunteers would benefit from a second level of training in performance skills. Increasing the activity in the network could be achieved by organising a conference on Maths Busking, and the network requires a paid director and a paid event administrator. It is anticipated that the volunteer network would be managed similarly to the STEM Ambassador network; to secure contracts for and manage the delivery of training days around the country, manage the delivery of performances, promote the project and fundraise.

The Project Team plans to establish Maths Busking as a subtrust of a charity or as an independent charity. Maths Busking provides services to other projects in STEM engagement such as training of performers, museum demonstrators, school teachers and youth workers. The Project Team expects to offer corporate training and entertainment too, while applying for funding to maintain charitable activities. In addition, there is a medium-term plan to organise a national maths week and a long-term aim to create a 'Mathematics Exploratorium' with exhibitions, activities, workshops, professional development for adults, performing arts, mathematical stand-up comedy and other forms of entertainment and education.

Science Van/Gwyddfan: Physics-based outreach, evaluation and prompt dissemination to Higher Education Institutions in Wales and the border regions

Project Lead: Debra Croft, Centre for Widening Participation and Social Inclusion, Aberystwyth University

Collaborating institutions: Institute of Physics; Swansea University

Abstract

Aberystwyth University has considerable experience in outreach activity in primary and secondary schools and in public/community projects. There have been a number of previous projects delivering science in innovative and exciting ways[1]. However, these projects have concentrated on biology, forensics, geology and earth and environmental sciences.

"Science Van/Gwyddfan" has taken the expertise and evaluations from Aberystwyth University's Science Circuit, the Institute of Physics' Lab in a Lorry[2] and Physicists and Primary Schools[3] to trial a set of outreach experiments in primary schools and at public events over the summer and autumn of 2010. The trial was intended to reach primary schools in the Ceredigion region during the summer and autumn terms and also reach out to the general public of all ages over the summer holidays in the rural areas of both Ceredigion and Powys.

A full evaluation of the events and a good practice document could then be used by other higher education institutions throughout Wales and also in the West Midlands and Borders areas.

Background and Rationale

Aberystwyth University, through The Centre for Widening Participation and Social Inclusion (CWPSI)[4], has considerable experience in outreach activity – in primary and secondary schools, and in public/community contexts – delivering science in innovative and exciting ways.

This project aligns neatly with one of the main strategic aims of the National HE STEM Programme to encourage activity to widen participation amongst students of school and college age. higher education institutions have an important role to play in raising aspirations and encouraging these students to engage in further study, and such activities and innovations provide curriculum enhancements.

The Project Team began by gathering together the evaluations and resources from previous similar projects. Next they developed a range of bilingual materials and sessions with physics themes and worked with and coached undergraduate and postgraduate students to help deliver workshops. The topics of the workshops included electricity basics, forces 1 – springs, forces 2 – gravity, the physics buskers' roadshow, physics-type 'Kitchen Science' experiments, and rocks and the Earth.[5]

[1]The Science Circuit project has completed phase II. For more details, see: http://www.aber.ac.uk/en/widening participation/schools/sci-circuit/. The Science Circuit programme is delivered working with the Wales-wide project Hands on Science and the Reaching Wider Partnerships. See: http://www.firstcampus.org/welcome-to-hands-on-science/ and http://www.hefcw.ac.uk/policy_areas/widening_access/reaching_wider_initiative.aspx

[2]For details, see: http://www.labinalorry.org/

[3]For details, see: http://www.iop.org/activity/outreach/resources/pips/index.html

[4]For details, see: http://www.aber.ac.uk/en/open-days/checklist/departments-and-services/cwpsi/

[5]For further details, see: http://www.aber.ac.uk/en/widening participation/schools/stem/science-van/

A number of the workshop sessions were based on proven interventions from the Institute of Physics adapted and translated to suit the students. The Team also added some of their own material, for example, role playing an electrical circuit with primary school children with children being bulbs, cells, wires, and so on. The new materials were prepared following discussions with staff, schools and the Institute of Physics. The Team already owned the van itself as a part of the Science Circuit project.

Implementation

One of the key points of good practice in working with schools in this way is the fostering of a good working relationship with the science specialist (if the school is large enough) or with the head teacher (in the smaller, more rural schools in the area). Such working relationships have been built up over a number of years and were essential for delivering events by Science Van within a short timescale.

When organising an event within a school, the Project Team were sure to ask the teacher of the group of students taking part what they would like covered from a selection of topics and activities (within the bounds of a particular subject area or project). For example, during this project it was intended to deliver some of the electricity sessions from the Institute Of Physics' Physicists and Primary Schools material. One school said they were working on the topic of materials and that the timescale of the Science Van project wouldn't fit, therefore a revised workshop was offered. Another teacher said they had a real problem with forces; they weren't sure they understood it properly and as a consequence it wasn't very well taught. Again, an adapted event was offered to take into account the change of topic.

In general, public/open events are harder to plan. At public events the doors of the Science Van are opened for all comers and can attract a diverse range of people. People of all ages, interests and abilities can attend. Activities, therefore, have to be very flexible in many ways. Use of the 'Physics Buskers'[6] is particularly useful in this context because their demonstrations can be delivered for all levels.

Sessions for the public need to be simple or stretching depending on the audience at the time and the people delivering the events need to be able to effectively communicate with all ages. Training for event providers is therefore important. Using undergraduate and postgraduate students is a very effective approach. Students are very enthusiastic and fascinated by their subject and communicate their enthusiasm well. Taking part in such events also provides excellent personal development for all the student ambassadors involved.

[6]For details, see: http://www.aber.ac.uk/en/imaps/news-archive/2009/may/busking/

Evaluation

All events run in schools were fully evaluated using a standard bilingual evaluation form. Return rates were high with 142 out of 143 forms being returned. Overall, 64% of students rated the events as excellent and a further 23% as very good. 95% of respondents said they would definitely like to be involved in more sessions. When asked what the students liked the best, it was always the 'doing science' elements – especially where these were noisy, smelly or perceived as 'risky' (e.g. stretching the stretchimals[7] to breaking point, stretching the elastic as far as it could go, or using the wind shooters[8]).

Teachers were also asked to complete evaluation forms and the data gathered to analyse the appropriateness of level, fit with national curriculum, ease of understanding for the children and so on. Feedback was entirely positive with requests for more and different sessions to take place in the future. In small rural schools, where the school does not necessarily have a science specialist, these outreach sessions can also serve as training and ideas for the teaching staff.

The public events were not evaluated in the same way in all cases, but were judged on numbers participating and the ratio of time spent in the Science Van or at other events or stands. However, when more formal evaluations were undertaken very positive feedback was received and 100% of respondents said they would like the opportunity to take part in more activities.

Discussion

The Project Team has successfully achieved the objectives that they set themselves at the outset of the project. However, the Team needed to be more flexible on the actual sessions delivered and the majority, but not all, were physics-based in the end. A full report including a compilation of the evaluations of the various outreach activities has been produced. Examples of resources and ideas have been produced in both English and Welsh and circulated to colleagues in Welsh and Borders higher education institutions. The learning and reports from this project have been made available on the Science Van website.

An Outreach STEM Seminar was held at Aberystwyth University for departmental colleagues (staff and students) to disseminate findings and demonstrate some successful techniques. It is hoped that this

[7]Stretchimals are a popular children's toy — a pliable and stretchy plastic animal shape. These toys can often be stretched to many times their own length and return to their original size and shape once released. For information, see: http://www.amazon.co.uk/s/?ie=UTF8&keywords=stretchimals&tag=googhydr-21&index=aps&hvadid=8154000954&ref=pd_sl_2zro4jl6w2_e

[8]The trade name for the wind shooter is Airzooka. Airzooka is a vortex generator. For information, see: http://www.firebox.com/product/567/Airzooka

seminar will increase the pool of ambassadors working in outreach over the coming year and beyond.

A key point in delivering successful outreach to young people, families and/or members of the public is to have a willing, enthusiastic, keen and knowledgeable team for different occasions. It is important to bear in mind that academics and 'grade A' students are not 'the general public' and the art of communication needs to be developed. It is a valuable and transferable employability skill for our scientists and mathematicians of the future, whatever walk of life they enter. It is also important to make sure departments know what and why they are needed – academics are often very supportive if they know you are not interfering with students' studies or research and understand that it is a benefit to them and also the future pool of students.

Think for a moment about your experience and reaction to a street busker. Often we can wander up a street and hear a musician in the distance, getting louder as we approach and then falling away again. The reason we drop money in the hat for some and not others is rarely based on absolute skill and musicianship, but more often on their ability to communicate joy and enthusiasm in what they do and engage with their audience.

Time spent training and mentoring delivery staff and students is amply repaid in the skills and flexibility they bring to the sessions they deliver. It is important to choose your team carefully for each situation and brief them thoroughly and carefully.

The Institute of Mathematics and Physics at Aberystwyth University has engaged more widely with Widening Access[9] as a result of this project which enabled us to deliver a highly successful Maths Challenge event.

Delivery for this particular project encountered barriers that may be experienced by other institutions keen to undertake similar work.

Working with schools in Wales is becoming increasingly difficult. This is primarily due to the 'Rarely Cover' policy that was implemented in recent years. Schools show an increasing reluctance to take pupils out of school for events. This is less true for primary than secondary schools but does mean that delivery in a school setting is the simplest for schools.

In a rural area, where a 'local catchment' for outreach for a University can realistically mean a 50km radius or more, travel is a significant cost both in time and money. This has implications for staff deployment, and in particular for the use of students as peer ambassadors, where delivery of an hour long session can take five hours of a student's time from start to finish.

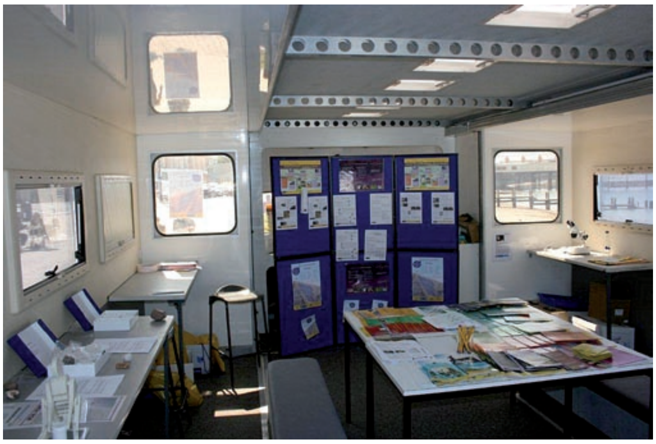
[9]For details, see: http://www.hefcw.ac.uk/policy_areas/widening_access/widening_access.aspx

Older children and adults often have a fear, dislike or even loathing of science and maths. STEM by stealth is a key method to breaking down these barriers. Going out to schools and public events is a great way to break down and overcome barriers. It is important not to use serious science and maths terms on advertising materials. Those people who are disinclined towards science and maths will be put off by it.

The Gwyddfan / Science Van funding enabled us to take the Cylch Gwyddoniaeth / Science Circuit brand and adapt it specifically for physics-based outreach, delivered in a new way, and bilingually.

Sustainability

The Project Team are pleased with the success of this project. The Science Van project continues in modified form. Science Van is now part of a wider offering and not just a physics-based activity. Science Van formed part of a series of Maths Roadshows that were successful[10]. The wider project will be repeated again in future years.



The Project Team are also looking into ways to change their methods of evaluation and also the way in which they offer sessions as outreach. Ideally, the Team would like more time to interact with the children and teachers to gain a better understanding of the impact their events are having.

[10]For details, see: http://www.aber.ac.uk/en/widening participation/schools/stem/maths-roadshow/

Lancashire STEM symposium – "Did you know…?"

Project Lead: Alan Darragh, Engineering Department, Lancaster University

Collaborating institutions: University of Central Lancashire; Blackpool Sixth Form College

Abstract

The Lancashire STEM symposium was deigned to promote the study of STEM subjects at university and the possible graduate career opportunities to pupils and teachers in and around the Blackpool and Fylde area. The project was to follow on from the success of similar "Meet the Scientist" events offered at Manchester Museum of Science and Industry (MOSI). This new symposium was designed to widen the positive impact of engagement with scientists and improve the links between Higher Education (HE) and schools/ colleges along with championing STEM disciplines.

This project aimed to deliver a number of symposia to include question-and-answer sessions with graduate scientists from the appropriate discipline spanning a range of careers in addition to current undergraduate and postgraduate students describing student life. This project was designed to act as a pilot to determine best practice for what is intended to be a long-term programme of activity to encourage hard-to-reach students to consider STEM as a career destination.

Background and Rationale

Staff at Blackpool Sixth Form College reported that many young people in the area did not recognise the benefit of studying STEM subjects, whether at college or in HE. The project was an opportunity to provide a series of positive workshops, talks and role models to potential STEM students of the future.

It was hoped that the project would provide support to an area of the north west of England with widening participation issues and a low number of students who are currently accessing HE. The project sought to increase the number of young people interested in studying STEM-related disciplines from the Blackpool, Wyre and Fylde Coast area.

The Faculty of Science and Technology and School of Health and Medicine at Lancaster University (LU) and University of Central Lancashire (UCLan) offered six fortnightly sessions themed around various STEM subjects. The sessions were designed for GCSE and A-Level pupils. It was also hoped that the sessions would be of general interest to teachers and college staff.

This project aligns with the National HE STEM Programme's aim for HE engagement with schools and colleges. While this project is a local initiative, it could be reproduced across higher education institutions throughout England and Wales.

Implementation

The majority of schools involved with the project do not currently have the opportunity to engage with higher education institutions and often miss out on the opportunity for pupils to be enthused and inspired about possible STEM career routes. This is in part owing to a lack of financial resources and transport difficulties. By using Blackpool Sixth Form College (BSF) as a hub and engaging with teachers the Project Team were able to interact with these hard-to-reach pupils. The project also offered to support schools with transport costs for the sessions.

Following an initial meeting with teachers at local schools, there was keen interest for these symposia to take place. It was originally hoped that around thirteen schools would take the available places. BSF dealt with all administration regarding the symposia, contacting and liaising with schools, and building on existing strong links already in place.

The sessions were designed to show the breadth and diversity of topics included within STEM. Six sessions were organised and were based on the following themes:

- Maths: The probabilities are endless (LU)
- What has the solar system done for me? (LU and UCLan)
- Microbiology – from tropical diseases to yoghurt drinks (LU)
- Physics research: Show me the money! (LU)
- Eruption disruption: How volcanoes can impact your life (LU)

- What is a watt? Switching on to Engineering (LU and UCLan)

"The support and funding from the HE STEM Programme allowed us to interact and engage with a group of students who wouldn't normally have the opportunity to speak to HE staff and students. We hope the sessions inspired some of these pupils to consider studying STEM subjects further within school and into HE."
Alan Darragh, Engineering Department, Lancaster University

Evaluation

The Project Team successfully delivered the programme of symposia. The project involved 11 schools and colleges from the area with around 500 pupils and teachers taking part. In addition, 25 staff from LU and UCLan were involved with the organisation and implementation of the sessions, and 15 undergraduate students from LU assisted with and facilitated the sessions.

To enable the sessions to be evaluated, after each session feedback forms for staff and students were distributed. Around 75% of students completed the forms but only 10% of teachers. The disappointing return of forms by teachers was owing, in part, to the forms being completed at the end of the session when teachers were also busy trying to organise various groups of students.

Students were asked to rank the session and comment on the level of difficulty. Other questions related to whether they had learnt something new from the session, whether the session made them want to learn more about the specific subject or theme and whether they hoped to keep studying the subject.

Overall the sessions were well received with over 90% of students saying they had learnt something new about STEM. Over 85% of students found the sessions to be good or very good with over 65% of students wanting to know more about STEM subjects. Pleasingly, over 60% of students said they wanted to continue studying STEM at school/college and HE. Where students found the session to be poor/fair it was typically when the session proved to be too difficult for the age group attending. The majority of students said the sessions had made them want to know more about the subject in the future. The feedback for the individual sessions varied a little but overall all of the sessions were very well received.

This project has helped foster relationships with staff and students at BSF and the surrounding schools.

Discussion

Both UCLan and LU were able to call upon the assistance of a large number of academic staff, support staff and students to help facilitate sessions. Both institutions recognised the benefit of the project in promoting STEM and assisting with outreach agendas. In total 30 staff members and students from LU and UCLan donated time and resources to the project.

BSF staff also committed considerable time and resources into ensuring that each session was a success and this extended to estates staff who assisted with arranging rooms for each session around busy lunch times and other events.

Although the project was a considerable success there were a number of barriers that the Project Team had to overcome. One major constraint was one of logistics. Coordination between LU, UCLan and BSF was sometimes difficult owing to time and work-load pressures. Issues also arose around finance because orders/invoices placed by BSF were difficult to pay when companies and schools were not on the university's finance system.

The programme also encountered difficulties regarding the venue for the symposia. Unfortunately the venue was compromised because building work at the college meant that there was a drastically reduced capacity. This put restrictions on session times and lengths. In most cases it meant a student question-and-answer session was not feasible. The room that was used for the talks no longer had a public address system. Consequently, a sound system and speakers needed to be obtained; the hire of which incurred an additional cost for the project.

The symposium at the beginning of the programme attracted good initial interest and positive attendance. However, numbers of attendees dropped after the half-term break. Schools also brought pupils of a range of ages from 13–17 although the sessions had been designed specifically for those aged 14–16. Having a mixed-aged audience from a large and diverse variety of schools meant that feedback was also extremely diverse; The same session could be deemed excellent by one school group and boring or too difficult by another.

The project attracted the attention of the local press in Blackpool who detailed the events[1] and a review of the project was published on the Lancaster University website[2]. A large number of t-shirts were designed

[1]For details, see: http://www.blackpoolsixth.ac.uk/news/latest/2010-10-21

[2]For details, see: http://www.lancs.ac.uk/sci-tech/schools/schools_news.php?article_id=1265

Students see stars in solar system talk

SOLAR POWER: Dr Jim Wild with Harriet Parry of St Aidans Secondary and Katie Faulkner

FROM crashing comets and nuclear infernos to greenhouse gases and mystical moons - Blackpool students were seeing stars as they explored the wonders of the solar system

Pupils from 10 local high schools joined students at Blackpool Sixth Form for an awe inspiring lecture given by a leading expert.

The illustrated talk, which was held at the college's Blackpool Old Road site was given by the University of Central Lancashire's top astrophysicist, Professor Don Kurtz.

The lecture, called What has the Solar System Done for Me? gave a whistlestop tour of some of the lesser known wonders of the universe.

It explored a number of mind boggling aspects such as the nuclear inferno at the core of the Sun to the frozen-air snows of the frigid moon Triton which is the coldest place ever explored.

The professor also spoke about monster hurricanes, canyons and volcanoes, weird and wonderful moons, crashing comets and discusses the death of the dinosaurs.

He also opened up a number of areas for discussion. He highlighted the vulnerability of the Earth against the harsh reality of the rest of the solar system.

The origin of the Earth's atmosphere was also under the microscope as the greenhouse effect and global warming are discussed.

Jon McLeod, head of admission for Blackpool Sixth Form said: "This was a fantastic lecture which was lively and engaging as well as very informative.

"We were delighted to see so many young scientists come to Blackpool Sixth Form College for the event.

"They certainly had their eyes opened to some of the amazing features of the Solar System.

"It's wonderful to be able to bring some cutting-edge science to Blackpool.

"We have growing numbers of students taking science courses and have an excellent track record of students progressing to top science courses at university. "

The event was part of a series of STEM (Science Technology Engineering and Maths) lectures and masterclasses which are taking place at Blackpool Sixth Form College this term.

The project is jointly organised by Blackpool Sixth Form College, Lancaster University and the University of Central Lancashire. Local high schools have been able to book places for their aspiring scientists and engineers.

and bought as part of the project and were distributed to all pupils and teachers at the final session.

The feedback shows that the sessions had a positive impact on the vast majority of students who attended. Where students indicated a lack of desire to continue studying a subject it was often on occasions where the sessions were based on a non-specific school subject (e.g. volcanoes, space physics, engineering). It is possible that students felt they could not continue studying these subjects as they did not currently study them within school/college. The subjects with a direct link to traditional school subjects (maths, biology and physics) all scored higher on the feedback forms than the more diverse sessions.

Sustainability

The project has led to improved links and relationships between all the secondary, further and higher education institutions involved. A number of schools involved in the project were also invited to take part in the National Science and Engineering Week sessions held at Lancaster University.

A follow-up meeting at Blackpool with the teachers and staff also took place. This meeting gave all parties a chance to review the impact of the project and consider future improvements.

The project overall has been a great success and all those involved benefitted from taking part. As a future concept, running STEM symposia at a hub venue and inviting surrounding schools and colleges is an effective use of staff time in promoting HE and STEM. It is paramount that all those involved ensure that the commitment required in terms of both time and resources is actually feasible. When so many different stakeholders are involved communication can at times be difficult and patience and perseverance is required. Other key suggestions of good practice are as follows:

- Feedback from schools suggests that holding the sessions monthly would be preferable to fortnightly
- Schools should ensure that the appropriate age group of students attend the relevant sessions
- For any sessions over an hour or with lecture formats the students benefit from a short break
- Students continually requested more interaction and involvement in sessions and it would be good to be able to include the students as much as possible

It is clear that similar symposia could be set up across England and Wales fairly readily given the time and effort of university staff members and local schools. Organisation appears to be a key point in ensuring attendance by students and success of these events. Symposia could be delivered on a diverse range of topics covering all STEM subjects.

Since the original symposia were delivered, a number of the sessions developed have been used for schools visits and events. Some of the material produced was used at the Big Bang Science festival held in London.

While the Project Team is keen to repeat symposia in the future, they are unsure whether this will be possible or not. Staffing issues have so far made repeating the symposia impossible, but there have been recent meetings to discuss future projects and events.

The funding received from the National HE STEM Programme helped support the schools with their travel costs to the venue each week. Future funding may be required to assist schools with mini bus/ coach costs to enable them to attend sessions.

Chemistry South West: Sharing best practice in widening participation

Project Lead: Bridgette Duncombe,
Department of Chemistry, University of Bath

Collaborating institutions: University of Exeter; University of the West of England; University of Bristol; University of Plymouth

Abstract

This project had two main aims. The first was to identify and build upon best practice found in higher education institutions throughout the southwest region of England. The second was to embed an existing pilot project into widening participation activities across the region. The pilot project was the Spectroscopy in a Suitcase[1] outreach activity which was developed by the Royal Society of Chemistry as part of the Chemistry for our Future Initiative. The results of the project were to include a pool of peers trained as science communicators and a discipline-based network of practitioners across the south-west region. The Spectroscopy in a Suitcase activity is targeted at school pupils to encourage them to consider chemistry for further study and/or as a career. However, a modified or similar activity could easily be applied to other subject areas, for example, physics and engineering. The lessons and learning gained from setting up a regional network of trained science communicators and practitioners are directly applicable to all STEM subject areas.

Background and Rationale

The southwest region of England is very diverse both geographically and economically. The south west is the largest, most rural region in England, with large parts of the region being poorly served by higher education institutions. Therefore, the Project Lead felt it was essential for the region to act as a unit. As a region it would be possible to support the development of aspiration and confidence in STEM subjects amongst the next generation of students and support and sustain the region's economic skills base.

This project aimed to pool existing expertise in widening participation found within the region. This would benefit chemistry primarily but the learning and networks could easily be transferred to other STEM subject areas. In addition, if such networks, and the mechanisms by which they operate, were successful in the south west then it is reasonable to expect that similar networks could be set up in a similar way. The project also took the existing Spectroscopy in a Suitcase activity and streamlined the process of delivery to maximise impact. Further to this, pooling of expertise and skills ensures that the science communicators, trained as part of this project, would have a high level of skill and a wealth of resources available to them. This project would also reduce the long-term costs associated with organising and delivering widening participation activities. Lower costs would allow schools and colleges in the most rural and poorly served communities to become involved. This project directly supported the training of postgraduate and undergraduate students in transferable skills and offers hands-on experience of careers such as teaching, science communication and science journalism. The development and success of the Chemistry – South West network will ensure that links between schools engaged in widening participation and higher education institutions are not dependent on the activity of a single institution but rather sustainable and strengthened through the collaboration of many such institutions with centres of expertise, known as nodes.

The National HE STEM Programme aims to enable the higher education sector to engage with schools to enhance curricula and to support graduates. This project mirrored the Programme's aims closely. By developing a network of institutions that are prepared to work together in key areas, the region's schools and colleges are well served. A network allows schools and colleges to work with the institution which is most appropriate for the activity that they want to run. It also allows the sharing of information on how best to market, plan, organise and run events, thus improving the experience for all involved. Importantly, such networks also allow for development and enhancement over time. It is easy to foresee new activities and training being incorporated

[1]For details, see: www.rsc.org/sias

to meet the needs of the region as the network strengthens and more nodes of activity develop.

Implementation

A planning and development meeting at the University of Bath was held to initiate the Chemistry – South West collaborative project and to discuss the main aims of the project. The main aims were to develop a pool of well-trained postgraduate and undergraduate science communicators and to develop a sustainable network of chemical science practitioners. The event was well advertised and many members of higher education institutions within the region attended.

The aim of the meeting was to discuss the types of expertise that could be transferred efficiently and effectively across the region in the area of widening participation and develop plans towards the types of activities that should be developed. In particular, it was important for colleagues to be able to showcase their expertise through invited talks and time was allocated to discuss these existing projects and allow participants to find areas in which they would wish to transfer best practice.

One of the actions resulting from this meeting was that delegates from the University of Bath and University of Plymouth decided to write a "Best Practice Guide" to Voluntary Peer Mentoring Schemes because both Institutions have experience in running such schemes and therefore had expertise and advice to offer in this area. Another action was that Dr Nicola King at the University of Exeter was asked to write a detailed manuscript of another project that she had been running in collaboration with a school in the Exeter area involving the production and sale of biodiesel. Both of these actions have been completed since this first meeting.

The primary aim of this collaborative project was to train a group of postgraduate and undergraduate students from across the region as science communicators. The training would equip them to take part in both primary and secondary school activities. This primary aim was decided at the cross-region meeting.

The training day for the students was held on Thursday 22 July 2010 at the University of Exeter and advertised widely across the south west region. The day was split into two main training sessions. Dr Gan Shermer from the University of Bath and Dr David Read from the University of Southampton facilitated the first session, which focused on using the equipment for the Spectroscopy in a Suitcase outreach activity. The Royal Society of Chemistry has recently loaned the equipment to the south west region for one year, and the use of the equipment is being co-ordinated by Dr Gan Shermer. The second session was facilitated by Mr Tim Harrison[2], Bristol ChemLabS School Teacher Fellow and Outreach Director, University of Bristol, who taught attendees how to work with primary schools to deliver outreach activities.

These practical sessions were interspersed with information on the possible future challenges of outreach work. Dr Gan Shermer gave a talk about working with schools and Dr David Read spoke about his experiences of using the Spectroscopy in a Suitcase equipment. In addition to the seventeen postgraduate and undergraduate students who attended the training day, a number of secondary school teachers were also trained.

Evaluation

Following the initial planning and development meeting, a number of teachers came forward to express their interest in using the Spectroscopy in a Suitcase equipment. Furthermore, Dr Gan Shermer has co-ordinated a programme for use of the equipment in the south west region across all of the Chemistry-South West network members over the next year.

The equipment started at Bristol ChemLabS, then moved to the University of the West of England, the University of Exeter and the University of Plymouth before ending its rotation at the University of Bath. Because postgraduate and undergraduate science communicators have been trained in all parts of the south west region, when the equipment comes to different parts of the region, communicators are on hand to make best use of it.

The Project Leads feel that the success of the Chemistry – South West network itself has been tempered by a number of factors. If there is a single driving node or institution for all activity, then it becomes easy for the rate of activity to slow when this single node becomes overworked or is unable to put in the required time for planning and advertising. The coordinators propose that a multi-node approach may be more successful because the workload is shared and the scale of activity is more manageable for any individual institution. It is clear that the success of these and the Chemistry-South West network itself is dependent on staff availability, particularly within the normal teaching period of higher education institutions and schools.

Discussion

The Project Leads strongly believe that the interventions developed as part of Chemistry – South West have a high level of quality assurance. Interventions were developed from existing national schemes, such as the Royal Society of Chemistry's Chemistry for our future project, and from regional best practice, such as the University of Bristol's ChemLabS outreach work. The project also took into

[2]For more information about the role that Mr Tim Harrison performs, see: http://www.chemlabs.bris.ac.uk/bios/Tim_Harrison.html

consideration other initiatives, such as The Mentoring and Befriending Foundation national peer mentoring scheme.

The training of postgraduate and undergraduate students was a particular success, making good use of everyone's time, ensuring that an excellent standard of training is delivered to all and engendering a real sense of being part of a network supporting regional needs.

One area where it was hoped further support would aid quality assurance was the suggestion to form a teacher board to assist and advise on the activities developed. Whilst this board has been formed, it has not been as successful as the Project Leads would have liked. The volume and nature of a teaching professional's workload has been cited as the main reason for teacher boards' underperformance. It should be noted that teachers are most willing to participate, however it is only possible for them to dedicate any significant time during non-teaching periods.

A number of members of the Chemistry – South West network have worked on further initiatives including a joint proposal written by the Universities of Bath and Plymouth on undergraduate placements. The Department of Chemistry at the University of Bath has one of the largest undergraduate placement schemes in the UK with between 50% and 70% students achieving a 44-week placement. Whilst the initial proposal was not successful, it has led to a closer working relationship between the departments. There has been open dialogue on placements and transfer of best practice between departments, including staff not originally involved in the Chemistry – South West network. Furthermore, more joint proposals and initiatives are being developed.

Sustainability

The Project Leads have achieved a number of the significant aims of this project. A significant number of peer science communicators have been trained to deliver outreach activities to primary and secondary schools. In addition, a number of best practice guides have been produced. In contrast, the Chemistry – South West network has proved more challenging to maintain.

Whilst training and production of best practice documents are relatively simple to implement and utilise, networks require continued input to thrive. Active networks often show significant dependence on a single node or institution. If organisation and work from this node slows the network can quickly become dormant. If a network is to be active as a whole, it requires facilitating with people responsible for advertising, follow-up and planning. The Project Leads believe that the network they established is sustainable, although not in the form it was originally envisaged. In the main, limited networks within the region remain active. This success has been driven by the support received from the National HE STEM Programme because it overcame any pre-existing geographic barriers and enabled collaboration.

Curriculum impact: Making explicit links for the HE mathematics curriculum to applications in science, technology, business and industry

Project Lead: Vivien Easson, School of Mathematical Sciences, Queen Mary, University of London

Collaborating institutions: Institute of Mathematics and its Applications

Abstract

This project concentrated on employability skills and related resources for mathematical sciences undergraduates.

The first aim of the project was to run a workshop to examine curriculum resources developed over the three previous years and to provide impetus for improving and transferring best practice and resources to STEM departments in other higher education institutions. The workshop would provide an opportunity for representatives from industrial and business sectors to meet with academic staff from mathematical sciences departments from across the UK.

The second aim was to prepare a booklet and accompanying video demonstrating to students where their maths skills might be best put to use in the workplace and demonstrating to employers what can be expected from a maths graduate.

Background and Rationale

At the start of this project, the Project Team believed that there was a real need to develop material and resources relating to specific topics in undergraduate curricula to real-world applications in science, technology, business and industry[1]. This proposal followed on from existing, evidence-based practice undertaken by More Maths Grads for the Key Stage 4 and Key Stage 5 mathematics curriculum[2]. An understanding of the key applications of a subject provides motivation for undergraduate students and enables them to make better-informed choices during and after their degree course. It also helps higher education mathematical sciences departments to explain their programmes to potential applicants, current students, potential employers and the general public.

The Project Team believe that it will be beneficial for the higher education STEM sector nationally for mathematical sciences departments to use the National HE STEM Programme as an opportunity to develop high-quality materials that enable staff to embed awareness of applications in the undergraduate curriculum. Depending on the style of teaching at a given institution, future resources might be used to provide interludes either as part of a traditional lecture or posted on the HEI's virtual learning environment. This project therefore aligns well with the National HE STEM Programme's aim to enhance the higher education curriculum by supporting STEM departments and faculties to enhance their learning, teaching, assessment and support practices.

A number of resources have been developed over the past few years, such as the Maths Careers website. Whilst these resources are helpful, it was felt that there was a need for more resources to be aimed at undergraduates. Therefore the support provided by the National HE STEM Programme, along with funding from the Institute of Mathematics and its Applications (IMA) and from Queen Mary's Student Experience Investment Fund, was used to develop the 40-page booklet "Where the maths you learn is used" and

[1]Existing useful information and resources for undergraduate, school and college students is available, see: http://www.mathscareers.org.uk/ and http://plus.maths.org/content/

[2]For details, see: http://www.moremathsgrads.org.uk/home.cfm

seven short videos collectively entitled "Advice from Employers to Mathematical Sciences Students".

The aim is for these resources to be available to mathematical sciences departments nationally to encourage students to relate the topics they study and skills they develop at university to their future career ambitions.

Implementation

The first aim was to run a workshop to examine the resources developed and provide impetus for improving and transferring best practice. The workshop was set up, advertised and facilitated by Vivien Easson, Queen Mary, University of London and colleagues Michael Yates, Wei Roberts and Karen Zirngast.

The workshop was targeted at academic staff with responsibility for undergraduate programmes and/or careers, which worked well. The Team drew on personal and IMA links and the university careers service to get employers involved. Around 40 participants attended the workshop with representatives from 14 different university mathematical sciences departments[3].

During the workshop participants were given resource packs and took part in focus groups. The Project Team are grateful to Professor Peter McOwan for providing Mathematical Magic boxes[4] to give to delegates along with their More Maths Grads' Maths in a Box pack and "Where the maths you learn is used" booklet.

The next aim was to produce a glossy booklet of applications of the mathematical sciences curriculum. Funding from the National HE STEM Programme was used to pay some of the production costs and for postgraduate research students to make suggestions based on their experience of teaching mathematics and astrophysics modules. The suggestions were then brought together and written and designed to form a booklet.

The final aim was to produce a video of advice from employers for mathematical sciences students. Filming sessions were set up at the Big Bang London event

[3]Delegates included representatives from the following higher education institutions: University of Cambridge; City University, London; University of Greenwich; Imperial College London; University of Leeds; London Metropolitan University; London School of Economics; University of Oxford; Kings College, London; Kingston University; Queen Mary, London; University of Reading; University of Southampton; University of the West of England. Workshop speakers included: Adrian Thomas, Network Rail; Edward Ellis, FDM Group (IT consultancy); David White, Statisticians in the Pharmaceutical Industry and Alan Stevens, IMA. The videos included representatives of IBM, EADS Astrium, NCETM, Transport for London, EDF Energy, AECOM as well as the companies mentioned for workshops

[4]For more details, see Case Study 10 from this report

and also at the workshop[5]. Sufficient film was required to allow production of seven short films covering the following topics: the importance of soft skills such as communication and team working; what employers look for; why maths graduates are sought after; industrial placements; graduate training schemes; advice to undergraduates; and advice to universities.

Evaluation

The Project Team strongly believes that they have met and surpassed the original aims set out for this project.

This project has had considerable impact at a number of different levels. Teaching assistants/lecturers are more aware of the applications of a topic when teaching it, thereby making classes more relevant to students, and departmental staff are more aware of the importance of teaching the applications of a given topic and how motivating this can be for students. At a faculty level the booklet produced by the Team has been held up as best practice and other departments have been urged to copy it. As a result, the economics and geography departments within the university are planning similar activities.

The project has also had an impact more broadly. A significant number of people from a diverse range of education institutions and industries attended the workshop. Not only did this raise awareness of the work of the Team, it also provided a unique opportunity for networking. The resources being evaluated were praised and are being requested by various HEI departments for use with their students.

Around 4000 copies of the booklet "Where the maths you learn is used" have been distributed to undergraduate and sixth-form students[6]. Copies were distributed to all mathematics students at Queen Mary, University of London and sent to 22 other higher education institutions[7]. In addition to hard copies, the booklet has also been downloaded a significant number of times. Furthermore, the videos have been viewed extensively[8].

Discussion

The impacts and outcomes from this project are noteworthy. The primary outcomes are notes in the evaluation section of this case study.

The Project Team acknowledges that considerable effort and time was put into this project by a large number of people. The willingness of a number of people to work overtime to meet production deadlines is also acknowledged. Without the efforts from these people, as well as the support from the National HE STEM programme, this project would not have succeeded.

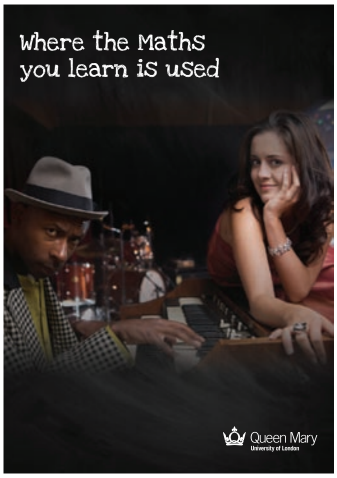
Despite planning well in advance of events and advertising well, it is difficult to get employers to attend to events. Several delegates sent their apologies at the last minute and one speaker failed to arrive at the workshop. Nevertheless, the opportunity to appear on a video offering advice to undergraduate students was highlighted and, anecdotally, this encouraged several people to come along to the event. Timings for events are also important. It might have been that a workshop held in November rather than July would be easier, but a summer workshop enabled a better turnout of academic staff. The Project Team believes that persuading employers to come to university-led events will often be an uphill struggle.

Sustainability

The resources developed as part of this project are freely available to others and as such can be used by others at other institutions easily. The experience and learning gained from this project could also be directly applied to all other areas of STEM and similar resources produced.

The Project Lead is keen to build on the project's success to date, but considerable pressure on time is likely to make future progress slow. Although it is unlikely that workshops will be run frequently, the resources already produced will continue to be used regularly. The successful running of this initial project was only possible because of institutional funding to employ and manage a dedicated Project Officer for 12 months.

The Project Lead is keen to hear from other institutions about how they use the booklet and videos. Currently, time pressures mean that other institutions cannot be proactively contacted for this information. However, collated feedback would be valuable and enable the resources that were produced to be revised.



[5]Following a competitive tendering process, wideangles.tv were commissioned to undertake the filming. For more details, see: http://www.wideangles.tv/

[6]The booklet "Where the maths you learn is used" can be requested by email to curriculum-impact@maths.qmul.ac.uk or a free pdf version downloaded from http://www.maths.qmul.ac.uk/undergraduate/impact

[7]The other higher education institutions to receive and disseminate hard copies of the booklet were: Coventry University; Heriot-Watt University; London School of Economics; Newcastle University; Open University; Oxford Brookes University; Portsmouth University; Plymouth University; Queens' University, Belfast; Swansea University; University of Abertay, Dundee; University of Bath; University of Bolton; University of Bristol; University of East Anglia; University of Exeter; University of Greenwich; University of Hertfordshire; University of Leeds; University of Strathclyde; University of the West of England and University of the West of Scotland

[8] The videos are hosted by the IMA. For details and to view the videos entitled "Advice from Employers for Mathematical Sciences Students", see: www.mathscareers.org

A proactive intervention to facilitate the transition to HE for engineering students with non-typical mathematical backgrounds

Project Lead: Stephen Hibberd and Ria Symonds, School of Mathematical Sciences, and Tom Cross, Faculty of Engineering, University of Nottingham

Collaborating institutions: Loughborough University

Abstract

This project sought to address the issue of good mathematics provision for engineering students who do not have a recent GCE A-level in the subject. Each year, a number of students entering engineering courses experience difficulties in making the transition from mainstream secondary education to the undergraduate demands in the area of mathematics. Drawing upon observations from recent teaching research, the Project Leads aimed to embed initiatives targeted at curriculum augmentation to assure integrated student support and monitoring.

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. A new proactive approach involved nominated students attending structured tutorial sessions linked directly to core maths topics. Such intervention should also result in improved student retention on engineering courses.

Background and Rationale

Students who have achieved a recent good pass at GCE A-level mathematics (or a close equivalent) dominate the intake to the degree course in engineering at the University of Nottingham. Consequently, study modules in the first year are well tuned to this intake. Previously, a parallel provision for about 20-40 students was also available for students from more diverse backgrounds but progression, mathematical confidence, motivation and engagement of this cohort were varied and the outcomes were often disappointing.

In addition, recent teaching methodology research and experiences have suggested inherent limitations with any dual-module approach[1]. A fundamental change had been promoted whereby the transition of 'non-typical' students is supported proactively thereby avoiding early differentiation in core mathematics ability. Therefore, it was determined that the primary aim of the project would be to develop effective, flexible and responsive support for students.

This project matches very closely with two of the primary aims of the National HE STEM Programme by supporting a well-defined curriculum development that focuses on course delivery and design, as well as supporting students directly. Enhanced student progression and retention is expected through improved student knowledge and skills. Further, this project also directly supports widening participation and non-traditional entry students onto a STEM-discipline course.

The Project Leads wanted to target students defined as 'at risk' of failing the transition to higher education and those involved in widening participation initiatives. An integrated system of support should enable engineering courses to admit non-traditional students (for example, those holding only diploma qualifications) without recourse to a Foundation Year. Support programmes, in the form of tutorials, would be developed and then delivered by specifically trained postgraduate student teachers. These student teachers also benefit from extended opportunities to broaden and enhance their skills through continued professional development.

[1]For background and research on dual-module approaches, see: R. Symonds, PhD Thesis, Evaluating student engagement with mathematics support, Loughborough University (UK), 2009

Implementation

The local Project Team developed the course alongside external specialist advisers[2] and materials for engineering students in mathematics. Work started in summer 2010 and continued until summer 2011 to develop specialist online support including leading-edge video, text and interactive tutorials. The work was undertaken in close liaison with the five departments of engineering at Nottingham to ensure that provision would be effectively tailored to the needs of the students studying a variety of courses. Proactive tutorial support reinforces the fundamental aspects of core topics enabling students to study the more difficult concepts during their normal lectures, tutorial sessions and private study alongside their peers.

The interactive tutorials were to be led by a group of six postgraduate student teachers. These postgraduate students had already completed some training and had first-hand experience of supporting students in problem-solving workshops. The postgraduate students then attended a half-day training workshop on leading more proactive sessions. It was noted that many of the postgraduate students found it difficult to deliver proactive tutorials and tended towards giving lectures. Therefore this training session provided a very valuable opportunity for each postgraduate student teacher to practice, and receive feedback on, running an effective proactive session.

Tutorial worksheets were produced weekly during the autumn term and fortnightly during the spring term which covered important formulae, examples, a checklist, and further help. Worksheets were easy to follow allowing students to monitor their own learning. Worksheets were linked to the timetabled lectures rather than providing too much new information which could be overwhelming.

Postgraduate student teachers were also given worksheets that mirrored those for the students. These sheets also contained points to elaborate and examples to demonstrate as an aid for delivery in the support tutorial. In particular, common misconceptions and mistakes were highlighted to the students. In addition, and to supplement an existing Virtual Learning Environment, a summer intern student compiled and linked materials and interactive resources to be used in conjunction with tutorial worksheets. Students were encouraged to use these additional resources whenever they had difficulties beyond their timetabled lectures/tutorials.

At the start of the academic year, students requiring support were placed into groups of 6–8 and given details of their weekly tutorial. Around 40 students took part in the new programme. A 'guideline' format for tutorials was suggested, but postgraduate student teachers were also encouraged to reflect upon the needs of the participating students on any given week. Initially, time was spent reinforcing important concepts and formulae and illustrating examples associated with the weekly topic. The remainder of the session was then used by the students to practice questions, discuss ideas and obtain specific help where needed. At the end of each tutorial, one or two interactive resources from the Virtual Learning Environment were recommended to support further learning.

Evaluation

A full set of support materials for tutorial sessions as well as training for those delivering proactive tutorial sessions was successfully developed and produced. While the provision itself has received positive feedback, a number of barriers were encountered throughout this first implementation and a number of procedural steps put in place and changes made to improve the experience for future students.

Late nomination or arrival of engineering students resulted in limited attendance at induction-week tutorials and also a delay in sending out some invitation emails. Uptake from students who arrived late was very poor, possibly because they no longer felt that the information was relevant or that it was too late to join in. Timetables also proved a logistical barrier. Support tutorials need to be allocated dynamically to match the students' engineering timetable, which was complicated and further compounded by unscheduled timetable changes by lecturers. For the most part, a convenient time was found for each group to meet. Now that this new support-tutorial system is established, it is expected that engineering course staff can better highlight potential candidates earlier in the academic session and inform relevant students upon admission.

To assist in the evaluation of the new tutorials, the students taking part were asked to complete questionnaires at the end of the autumn term regarding their attitudes towards mathematics and their views of the support. Analysis of this data suggests that the tutorials helped to build confidence amongst the students. Data from a second questionnaire reported a positive impact. Generally, students felt more confident because they were able to get specific help with topics and discuss ideas with their peers. Support and monitoring for the postgraduate student teachers was also provided. Feedback from the postgraduate student teachers was very positive; they welcomed the greater involvement with undergraduate teaching and their personal development through hands-on teaching skills and experience.

[2]The Project Lead acknowledges encouragement, support and specialist advice from external advisers Dr C. L. Robinson, Mathematics Education Centre, Loughborough University, and Dr J. Kyle, University of Birmingham

Creation and development of a tutorial – based comprehensive and pedagogically informed proactive intervention has been enabled with support from the HE STEM Programme that has been established as a new embedded option in helping nominated Engineering students through the qualifying year in engineering mathematics.

Stephen Hibberd, School of Mathematical Sciences, University of Nottingham

Discussion

This very successful new programme, developed for students admitted to engineering degree courses at the University of Nottingham, is set to continue in its current form to support each new cohort in future years. 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. Awareness is raised in all staff regarding mathematics requirements for new students and the support available to them. Knowing that support is available for students enables staff to target their lecture material to the 'traditional' entry students with confidence.

The support provided by the National HE STEM Programme enabled wider consultation, management, development and evaluation of this new initiative, including developing an online framework of support as well as evaluation and collation of existing materials. Ongoing costs associated with training of postgraduate student teachers, maintenance of online resources and course delivery are budgeted within the School of Mathematical Sciences.

This proactive intervention was also evaluated by comparing the performance of standard intake students to that of students receiving support and that of students who had not taken advantage of the support on offer. Interim results at the first autumn term showed students receiving support performing at a similar level of mathematics capability to that of the main student cohort. Their performance dropped in the spring term, possibly owing to the increased demands of that module or the fact that support provision was reduced to fortnightly. Overall, supported students attained a pass rate commensurate with previous cohorts on the dual-module approach, even though taking a more demanding module. Students who did not take advantage of the support showed a wider variation in capability and performance. This provided valuable feedback on the groups of students particularly at risk.

Sustainability

This successful programme is to be offered indefinitely to all new engineering students from non-typical mathematical backgrounds. Several procedural changes and improvements have been made following constructive feedback received from the first cycle of students taking part in this initiative. The ongoing running and training costs for the current programme have been embedded into the university's routine provision to ensure continuity of service.

The outcomes and learning from setting up and running this programme for the first time have been disseminated at national and international meetings[3].

It is easy to envisage that the framework developed for engineering students could be adapted and applied to students of other STEM disciplines. Adoption of similar programmes in the departments of physics and astronomy began in September 2011.

[3] R. Symonds, S. Hibberd, T. Cross, A proactive intervention to facilitate transition to HE for engineering students with non-typical backgrounds. Proceedings of the 7th conference Mathematical Education of Engineers, Loughborough University, 11 April 2011. ISBN 978-0-905091-25-9; R. Symonds, S. Hibberd, T. Cross, A proactive intervention to facilitate transition to HE for engineering students with non-typical backgrounds – experience over an academic session. Proceedings of the CETL-MSOR Conference, Coventry University, 5–6 September 2011; Oral Presentation to representatives of the Engineering Faculty, September 2011

Constructing a coherent STEM strategy with schools

Project Lead: Alison Hooper, Faculty of Environment and Technology, University of the West of England

Collaborating institutions: University of Plymouth

Abstract

Most universities run STEM enrichment activities with local schools. The aim of this project was to embed into the University of the West of England (UWE) the good practice from the University of Plymouth regarding their coherent STEM approach to school liaison. Although UWE runs a number of outreach events in mathematics (Maths Challenge, Maths Events Day and FunMaths Roadshow), engineering (Bloodhound[1]) and science (Science Awareness Day, Hands On Science Day, Bristol Festival of Nature[2]), these events are not integrated.

To attract students to study STEM subjects at university, it is necessary to enthuse school pupils before they make subject choices at GCSE and A-level. A coherent day of events would therefore best serve the students. The aims of this project were to:

- Inspire pupils with respect to STEM subjects
- Encourage pupils to aspire to university to study STEM
- Promote careers in science, engineering and maths
- Make connections with school STEM curriculum to enhance learning

Background and Rationale

Schools are asked to take part in numerous initiatives from a wide variety of sources and staff experience difficulties when attempting to schedule all the initiatives on offer. Collating STEM activities into a one-day event would facilitate scheduling for teachers. A single day of events also benefits pupils, who may not be encouraged to take separate sciences at GCSE, to see how the different STEM subjects relate rather than address each subject in isolation. In particular, it is important that pupils appreciate the key role of mathematics in all the sciences. The University of Plymouth Science and Technology Opportunities Project (STOP) activity is a model for delivering STEM activities in one school visit. UWE staff, who are involved in school activity work, are interested in the good practice developed by the University of Plymouth and learning from them.

higher education institutions do not have infinite resources to run school liaison activities. Therefore, activities need to be efficient, particularly regarding staff time, yet also of high quality to achieve the result of attracting students to STEM subjects. higher education staff need to find any single STEM resource straightforward to run with minimal preparation time. Shared activities among many staff means they would also reach a large number of schools in a region.

The partnership between UWE and the University of Plymouth should help develop current activities for use in future STEM liaison work. Past experience with schools by both partners suggests that, for years 8–10, schools prefer visits to them rather than pupils visiting the university.

The UWE STEM Activity Day should provide an excellent opportunity to promote the More Maths Grads' Maths in a Box[3] resource that has been sent to every secondary school in England. The resource was already being promoted through STOP days run by the University of Plymouth. The day also fits in well with the aim of the National HE STEM Programme for higher education institutions to engage with schools and colleges.

Implementation

The Project Team believes that this project has been very successful and has achieved all of the aims set.

Two activity days were run. The University of Plymouth ran the first day, and the second day was a pilot run by UWE. The pilot was based on the University of

[1]For details, see: http://www.bloodhoundssc.com/car/the_scientific_and_engineering_challenge.cfm

[2]For details, see: http://www.bnhc.org.uk/home/festival.html

[3]It is clear from contact with schools during this project that Maths in a Box resources were being under-used or not being used at all. Some teachers were unsure of how to use the resource and this project provided an opportunity to explain to teachers how best to use this extensive resource better. An additional 30 Maths in a Box packs were distributed during the activity days. For details and to download materials, see: http://www.mathscareers.org.uk/viewitem.cfm?cit_id=382988

Plymouth model. Staff from UWE evaluated the STOP activity run by the University of Plymouth, sharing best practice and learning how a comprehensive day of events could be delivered to students.

Good practice was shared through university staff visits: University of Plymouth staff visited UWE to view a FunMaths Roadshow run by UWE staff. Similarly, UWE staff visited a school in Devon to view a University of Plymouth STOP day. Based on experience gained from the visit to the STOP day, UWE staff put together the UWE STEM Activity Day. Some of the ideas from the STOP day were used and other new activities, based on UWE staff expertise, were developed. The UWE STEM Activity Day consisted of the following six activities:

- Dynamics
- Bubbles
- Aerodynamics
- Sound
- Microscopic Life
- Genetics

The pilot day was evaluated with input from an external evaluator to ensure good feedback and enable UWE staff to make any modifications and changes as needed. A questionnaire was circulated to all pupils taking part in the day's events. From the data provided by the questionnaire and from interviews with some pupils and teachers afterwards, the evaluator was able to measure the effectiveness of the day. The Maths in a Box resource was promoted at all the activity days.

"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 career sin STEM areas."

Alison Hooper, Faculty of Environment and Technology, University of the West of England

Evaluation

This project successfully met all of its aims and objectives. A pilot STEM Activity Day, based on the University of Plymouth model, was run by UWE at a Bristol school for 270 year-8 pupils. The feedback from event was very positive. Students clearly enjoyed the activities finding them both interesting and fun, inspiring them about STEM subjects. Overall the day was well received and marked the beginning for the process of development for this type of activity for pupils to help them understand STEM and its career opportunities. The event had a positive impact on the students' perception of STEM subjects in general. The event was also very well received by teachers.

Discussion

The funding received from the National HE STEM Programme for this project enabled the Project Team to share good practice between the University of Plymouth and UWE and gave each institution ideas about developing new initiatives.

Good STEM activities for the UWE STEM Activity Day were created. The activities themselves required careful planning and the three key staff involved met regularly to review progress. Input from technical staff was essential for building equipment and helping to develop ideas.

The school provided a good venue for the day, a large hall with seating to one side and sufficient power sockets for the equipment.[4] The evaluator[5] and Project Lead discussed beforehand the aims of the day and together they constructed an appropriate questionnaire.

A key feature of this project was the implementation of the day itself. While the pilot day was a great success, it was expensive to run, costing ~£2060. This money covered the costs and travelling expenses of 12 student ambassadors, one technician and three academic staff. Importantly, the event costs did not include the time spent liaising with the school before the event, (approximately half of the total staff time) or the cost of training the student ambassadors before the event (~£160 per student). The Project Team are keen to reduce costs for future activity days, particularly those of the academic staff by reducing cover from three to two or one staff member. Established University of Plymouth STOP days cost ~£110 per school visit.

The Bristol Local Authority was instrumental in finding a school and arranged for meetings to work out how the day would run. The Bristol Local Authority became involved at the start of the project and their input was invaluable, helping to decide the aims and objectives of the UWE STEM Activity Day.

[4]Brislington Enterprise College was involved in the pilot event

[5]It should be noted that it can be difficult to find an independent evaluator who is not involved in similar projects and can provide constructive feedback. The Project Team gratefully acknowledge the work of Sue Ponting in this regard.

The activity day requires careful planning and close liaison with the school. After an initial meeting with the school the Project Team agreed to run a STEM activity day for 270 year-8 pupils. The day was highly structured. Three batches of 90 pupils (split into six groups of 15 pupils) rotated around the six STEM activities, spending 12–15 minutes at each activity. Two student ambassadors manned each activity.

Sustainability

The Project Team believes that this project has had considerable broad impact. Since the original project ended, UWE has run a further four STEM Activity Days at four separate schools in the Bristol area reaching a total of approximately 1000 year-8 pupils during the 2010–11 academic year.[6] The results of the project have also been presented at the Inspirational Outreach workshop at the University of Exeter.[7]

The activity days will also continue in a slightly modified form. The Science and Mathematics Local Authority hub has put a list together of schools interested in taking part in a STEM Activity Day. All the schools that have already taken part would like a further opportunity to do so. The Team is proposing to run 4–5 STEM Activity Days per year. Funding for these events has not yet been secured but it is hoped that the money will be found from within the university. The activities developed can also be used at open days and other university public engagement days.

It is easy to envisage other universities setting up very similar days of events for use in their areas. This project, along with the STOP days run by the University of Plymouth, provides a blueprint for such events. Enthusiastic academic and technical staff are key to project success. Staff time is always underestimated. The time that would be required to liaise with schools and the Local Authority before a visit was not factored in to the Team's plans.

[6]The schools involved were Orchard School, St Bedes School, Ashton Park School and Fairfield High School

[7]Alison Hooper presented this project at the Inspirational Outreach workshop at the University of Exeter, 23 June 2011. For details, see: http://blogs.exeter.ac.uk/outreach/blog/2011/05/17/inspirational-outreach-workshop-invite/

Transferring the magic to STEM

Project Lead: Peter McOwan and Matt Parker, School of Electronic Engineering and Computer Science, Queen Mary, University of London

Abstract

The success of using magic and conjuring tricks as an entertaining and informative method to engage students in learning the fundamentals of STEM subjects was successfully piloted in the More Maths Grads[1] project by, among other efforts, the Manual of Mathematical Magic[2] legacy product.

This current project aimed to transfer and adopt this curriculum intervention approach beyond maths through the production of a series of downloadable 'Magic of STEM' teaching materials[3] promoting cross-curricular STEM fundamentals. Teaching resources would comprise pdf resources and videos for promotion to schools. Challenging students to explain 'impossible' magical effects is arguably the purest form of enquiry-based learning and leads to deeper understanding.

The easy-to-perform tricks engage students; trying to work out 'how it is done' invokes students' analytical problem-solving skills; and the reveal of the 'solution' is explained by the underpinning science and leaves a lasting impact on the students. This project also aimed to work in partnership with a series of public events for students to raise awareness of the project and its aims.

Background and Rationale

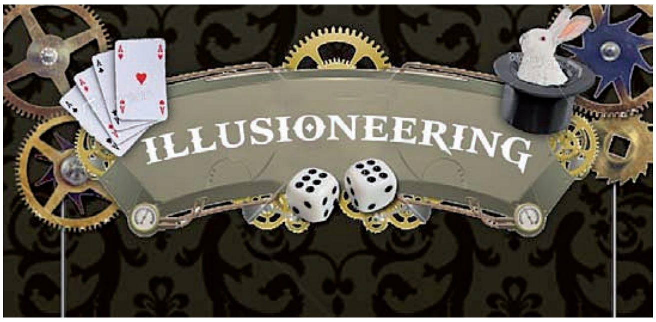
Magic tricks have the power to entertain us, and arouse our curiosity as to how the seemingly impossible can happen. Scientific or mathematical principles are often ingeniously concealed behind the magic. Unravelling the mysteries of the natural world both uncovers big ideas and reveals scientific misconceptions. Magic has the power to promote 'cognitive conflict' that can lead to an all important conceptual change and deeper learning. The 'Magic of STEM' project took advantage of these engaging tricks to propel students and teachers onto the path towards enquiry-based science and maths education.

Implementation

The project team initially consulted with teachers and scientists to explore possible areas for the development of STEM magic activities. Once these activities had been decided upon, written descriptions of the overall magic effect were written along with performance notes and a description of the underlying science explaining the trick. Once the tricks were developed they were then checked by experts to ensure that they filled the criteria for a good trick as defined by the project team. The criteria were:

- Entertaining and challenging for students
- Embeds hidden STEM basics at a suitable level
- Easy to perform and deliver in schools
- Well exposed tricks, i.e., tricks that have already been explained in the public domain. This criteria was set to ensure appropriate ethical consideration of the 'magicians' code' of not revealing secrets

A series of instructional videos showing both the performance and the science behind each trick were commissioned. These videos formed the basic content of the project's website. The website portrays a contemporary brand identity for the project, which is important if it is to make an impact on schools and school children, and was developed in consultation with media experts. The name for the website — *Illusioneering* — the Project Team feels encapsulates the concepts as an easy-to-remember brand that draws on the currently popular steampunk movement[4] for inspiration.



A series of national profile-raising stage shows followed in Easter 2011. These events attracted significant media coverage through, for example, the flagship BBC radio show Material World[5] and sell-out shows at the British

[1]For details, see: http://www.moremathsgrads.org.uk/home.cfm

[2]For details and to download a copy of the manual, see: http://www.mathematicalmagic.com/

[3]For details, see: illusioneering.org

[4]For an explanation of the steampunk movement, see: http://en.wikipedia.org/wiki/Steampunk

[5]For details, see: http://www.bbc.co.uk/programmes/b006qyyb

Science Festival 2011.[6] The success of the initial project assisted the Project Team in leveraging additional funds at a faculty level from Queen Mary, University of London, (QMUL) to produce a printed book of the resources which is also now available for download from the project's website. The book contained a foreword by magician, video-games pioneer and space entrepreneur Richard Garriott[7] and also includes the tricks that he performed during his visit to the International Space Station. The book was officially launched by Richard Garriott and Lucy Hawking (children's novelist and daughter of Professor Steven Hawking) at an educational event held in the House of Commons in December 2011, and was subsequently widely distributed to enthusiastic STEM teachers at the Association for Science Education conference in Liverpool in January 2012.[8] Richard Garriott has also been informally promoting the work of this project within the United States.

Evaluation

The Project Team measured the impact of their project by a number of means. They took into consideration the number of downloads from the project's website, the number of delegates attending events, feedback received from content on the website, feedback given during informal interviews and input by teachers and pupils, and media uptake and response. High quality was assured by consultation with appropriate experts during the development and deployment phases of the project, and through a final project evaluation.

The project involved and engaged with the following:

- 5 Academic members of staff were involved in developing the activities
- 6 School teachers were involved in advising on the activities planned
- Approximately 150 students were engaged by the project at three national shows
- Videos received 3,600 views on YouTube (correct as of 7th September 2011)
- Website received 1,149 visits (correct as of 7th September 2011)

It was the initial success of the project in schools, at events and on the website that spawned the interest of the BBC to cover the project and subsequently result in the invitation to the Project Team to present elements of their magic show at the British Science Festival.

[6] In 2011 the British Science Festival was held in Bradford. For details of the festival itself, see: http://www.britishscienceassociation.org/web/britishsciencefestival/

[7] For Richard Garriott's personal website, see: http://richardgarriott.com/

[8] For details on the Association of Science Education and the conferences it runs for teachers, see: http://www.ase.org.uk/home/

The project was featured on the BBC Radio 4 show 'Material World' as part of a programme named 'Milgram's Obedience Studies, the science behind illusioneering and our lopsided moon' which was originally aired on Thursday 4 August 2011. The corresponding podcast was downloaded 194,791 times in the month following its release.[9]

The project received a good deal of positive feedback from the events the Team ran. Typical comments received following shows at schools included: "*Great make the show longer!*", "*It was great*" and "*More tricks please*".

Students attending events were also asked to rate the show that they had seen. Audiences were frequently made up of both science and arts pupils. For example, ratings on completed feedback forms from one show (with 20 students):

- 90% rated the show as good
- 75% rated the science as interesting
- 65% mentioned they have learned new things as a direct result of the show

Attendance at events has been good and the Project Team continue to advertise with schools to improve uptake further.

"The HE STEM funding made possible a new way to engage and enthuse teachers, students and the public about the magic of STEM, and the STEM in magic."

Peter McOwan, School of Electronic Engineering and Computer Science, Queen Mary, University of London

Discussion

The Team feels that the key enablers for this project were: good access to experienced media and design experts; good access, through personal network links, to enable integration with existing schools-event delivery mechanisms; good access to teachers and students for informal feedback during the development stages.

One significant barrier in the initial plan was the stand-alone, and possibly niche, nature of the magic events and their incorporation into existing school timetables. This risk was mitigated in consultation with teachers through their professional networks, who recognised the educational, wide-ranging and inspirational elements that the project had to offer.

[9] To download podcasts of the BBC show Material World, see: http://www.bbc.co.uk/podcasts/series/material/all. To download the podcast featuring this project, see: http://www.bbc.co.uk/programmes/b012wzpb

Subsequently, these teachers made time, space and large multidisciplinary student audiences available for these show to be delivered successfully.

Sustainability

This project is expected to continue in its current form and will feature in faculty outreach work and publicity. A number of faculty members are considering using the resources in first year teaching, and the Project Lead has been mentoring around four staff members on making science teaching interesting and accessible through the experience gained in this project. The development of the tricks included a number of academic staff from QMUL who are now considering using the videos in teaching and schools talks.

Furthermore, the project will also be a core element in an upcoming European Commission Science and Society[10] grant proposal, which is currently in preparation, to transfer elements of this work to teacher-training programmes in other European Union countries.

This project, the resources that had been developed, and the website will be maintained after the funding from the National HE STEM Programme completes, as part of the overall faculty outreach strategy. Shows will be performed and funded by the university's new Centre for Public Engagement. The Project Team has also secured additional £1,000 of funds from the National HE STEM Programme to produce additional videos focusing on maths and magic which will be developed and archived online.

Additional funding of £1,000 has also been secured from the QMUL Science and Engineering faculty to develop a printed book of the resources for schools that will be distributed through faculty teachers' events in various schools and also through the QMUL Centre for Public Engagement. This full book will also be made available through the website. The *Illusioneering* project will feature in faculty publicity materials, since it usefully blends science from all the faculty's schools, thereby continuing its dissemination to teachers, pupils and the broader public.

The Project Team has a number of pieces of advice for those interested in undertaking similar projects. Plan early and take the time to get things right by talking and getting feedback from other stakeholders. Where possible, link yourself with existing, broad and well-established schools' activities to maximise audience impact. Within this existing framework, where appropriate, establish your individual activity's brand, and promote it as widely as possible. Think about how you can make your projects as media-friendly as possible, and make the effort to engage with media partners. And finally, think about the project legacy, and ask yourself "what can it leave behind for others to use?"

[10]For information regarding the European Commission's Science and Society programme, see: http://ec.europa.eu/research/science-society/index.cfm?fuseaction=public.topic&id=1221&CFID=11463444&CFTOKEN=86e9dddd7ecefd42-1EB802C4-CE75-E21E-C1D91DA7320EE9CC&jsessionid=b10180c5a27f65c05488605133553522d614TR

Sharing best practice in STEM outreach: How to make friends and influence people!

Project Lead: Karen Moss, Centre for Effective Learning in Science, Nottingham Trent University

Collaborating institutions: University of Nottingham; Loughborough University; University of Leicester; Higher Education Academy Physical Sciences Centre

Abstract

Universities in the East Midlands have a sustained record of effective collaboration in HE STEM outreach based upon the activities of the pilot projects of Chemistry for our Future[1], Stimulating Physics[2], the East Midlands STEM Centres for Excellence in Teaching and Learning[3] and the East Midlands Space Development Agency funded flagship East Midlands Space Academy programme.[4]

The aim of this project was to share best practice derived from these programmes for the benefit of other higher education institutions, schools and colleges. A key aim was to share experiences with other STEM subjects and lay the foundations for long-term outreach collaboration.

The experiences would be shared through an event for practitioners as well as the publication of some supporting case studies including a model of staff development that could be used nationally.

Background and Rationale

The Project Team wanted to disseminate best practice from their extensive work through an innovative programme of interactions and development sessions for other higher education institutions, including live sessions with schools and colleges. The Team felt that sharing their experiences would be of benefit for all STEM subjects and other higher education institutions and would lay the foundations for longer-term HE STEM outreach collaboration between institutions and disciplines.

The Project Team's defined their objectives as:

- Organise a showcase STEM Outreach event with multiple HE contributions for a range of age groups from regional schools/colleges
- Offer a parallel structured programme for the HE sector on how to design and run activities in a range of STEM disciplines
- Share lessons on collaborative working with multiple higher education institutions, professional bodies and employers
- Produce a set of case studies for the HE sector

Implementation

A good deal of organisation and preparation was put into the STEM Outreach event before its delivery at Nottingham Trent University and its parallel programme of outreach activities. The events were:

- The Centre for Effective Learning in Science (CELS) Celebration Event for schools[5]
- An academic HE conference – Outreach in Collaboration III

The key feature of this activity was that it embraced a multi-institution, multi-subject approach. A particular innovation was to include observation of outreach in action (as part of the

[1]The Chemistry for our Future programme was a £3.25 million pilot project, funded by the Higher Education Funding Council for England between September 2006 and August 2008. The Royal Society of Chemistry managed the project. For more details, see: http://www.rsc.org/Education/CFOF/

[2]For details, see: http://www.stimulatingphysics.org/

[3]The centres involved were the Centre for Effective Learning in Science, http://www.ntu.ac.uk/cels/; Genetics Education Networking for Innovation & Excellence, http://www2.le.ac.uk/departments/genetics/genie and the Physics Innovations Centre for Excellence in Teaching and Learning, http://www8.open.ac.uk/opencetl/physics-innovations-centre-excellence-teaching-and-learning

[4]For details, see: http://www.emstempartnership.org.uk/WhatIsSTEM/EmdaSTEMProgramme/The+Space+Academy/

[5]For details, see: http://www.ntu.ac.uk/cels/outreach/events/95522.html

CELS Celebration Event) as part of the HE STEM conference on best practice in STEM Outreach.

The day was a great success and the measurable outputs were:

- 352 pupils from 14 schools took part in the CELS Celebration Event. This number included 49 pupils from the local Home Educators Group
- 50 people registered for the conference

The Project Team coordinated with a number of partners to take part in the events. The partners for the Schools Celebration Outreach Event were:

- Loughborough University – Department of Chemistry
- Leicester University – Department of Chemistry
- University of Nottingham
- Nottingham Trent University – School of Science & Technology, Art & Design, School Colleges and Community Outreach
- BioKNeX Education Lab
- Ignite
- GENIE CETL – Leicester University
- CELS CETL – Nottingham Trent University
- Connexions (careers service)
- Institute of Physics
- Royal Society of Chemistry

There were also a large number of contributors to the HE STEM Outreach in Collaboration III. Taking part in the workshops were:

- SpectraSchool and Spectroscopy in a Suitcase – Paul Cullis, University of Leicester, Chemistry
- Interdisciplinary Master Classes – June McCombie, University of Nottingham, Chemistry
- Code Breaking & Sustainability – Tracey Dickens, University of Leicester, Interdisciplinary Science
- Minds-on Science Outreach Activities – Karen Moss, CELS NTU

Those presenting talks were:

- Running an Integrated STEM activity – Katy McKenzie, University of Leicester, Chemistry
- '2 for 1: Designing and delivering Multi Institutional Events – Combining outreach with CPD – Paul Cullis and Sue Bull, University of Leicester, Chemistry and SLC
- Student Engagement with Outreach – Cas Kramer, University of Leicester GENIE CETL
- 'Doing it CELS style' – Karen Moss, NTU CELS

The organisation, advertising and registration were undertaken jointly by the UK Physical Sciences Subject Centre and CELS at NTU.

Following the two conferences, the Project Team produced a set of six case studies on best practice in outreach and working with schools & colleges. These case studies were uploaded on the HE STEM and UK Physical Science Centre website and are available to the public.[6] The titles of the six studies are: Grätzel Solar Cells Workshop; Problem-Based Learning Masterclasses; Interdisciplinary Masterclasses in Chemistry, Physics & Astronomy: Seeing the Unseeable; Spectroscopy in a Suitcase Workshops; Using Electronic Voting Systems ('Clickers') to Engage People with STEM Activities; and School Design Challenge (Engineering)

Evaluation

This project has been successful with the Project Team meeting all of the aims that they set out for themselves at the start.

All of the presenters taking part in the two conferences either had a previous track record in outreach from earlier higher education projects or came highly recommended. The Project Team formulated their evaluation strategy during the planning stage of this project, and had significant support from colleagues at NTU as well as a team of HE STEM outreach practitioners who had worked together as partners in previous events. This existing network was a great help in planning, communication and coordinating activities.

The scale of the event was challenging to deliver given the number of partners involved and the number of potential participants who needed to be contacted and kept up to date. The events attracted fewer post-16 pupils than had been hoped. A possible explanation is that, in general, outreach groups have experienced some difficulties in getting schools to visit university sites, even for activities which are free of charge, unless they are given six months notice. This problem appears to be an unintended consequence of the 'rarely cover' schools' policy. It affects secondary schools more than primary schools and looks like being an increasing problem for the HE sector when attempting to attract Key Stage 4 and 5 pupils. The fact that a lower number of students attended than anticipated supports the hypothesis that STEM activities should be offered at schools rather than universities.

[6] To view the full case studies, see: http://www.heacademy.ac.uk/physsci/home/projects/OutreachWideningPart

Discussion

Evaluation of the events by HE attendees was done using standard UK subject centre forms. The 'best thing' about the event was 'networking' but 'seeing outreach in action' was also cited frequently.

The project also hopes to impact on future practice by others. Examples from attendees are:

- "*My student attended your workshop on the voting systems. There is currently funding in our school which I'd like to bid for and I think the clickers would be ideal*"
- "*Very useful sessions. Lots of ideas for outreach activities in technology. Good to think about integrating subjects and integrating with universities*"
- "*Very useful plenary discussion. Much food for thought and I leave inspired with ideas for the future*"
- "*The student engagement presentation was excellent and I leave with plenty of ideas for inspiring my students to get involved in outreach*"
- "*I am going to seek cross-college support for outreach and hopefully will collaborate with GENIE (University of Leicester) now I'm aware of the full range of activities they do*"
- "*Renewed enthusiasm for outreach*"

A separate evaluation process was carried out for the presenters. These raised few issues. Teachers and pupils were also given evaluation forms, however the return rate for these was low.

The most helpful were answers regarding which activity they had enjoyed most (Magic Tricks and Maths Buskers were highly rated alongside Biomechanics Sports activities, DNA activities and fingerprints). Students also mentioned that they had learned something by attending. One question on the evaluation form asked each primary school pupil to recall one fact that they had learnt about science and university during the day. This question led to answers such as: "*Electromagnetism pulls through skin & muscle*"; "*The right side of the brain controls the left side of the body*"; "*University is very fun*" and "*University is a lot of work*".

Attendees from the teachers and Home Educators Group rated the event as "*Useful*", "*Mostly relevant*" and "*Worth doing*". The 'best thing' was identified as "*Use of equipment (micropipettes) pupils hadn't been exposed to before*"; "*Fun with flames - lots of demos backed up by accessible relevant theory.*"

A few areas for improvements have also been identified. It was clear that this scale of activity caused some practical problems – for example there were sessions offered to schools that were not booked or were over-subscribed. Some schools felt they wanted more details about the sessions in advance than had been provided. Whilst ratings were generally high, one or two sessions were criticised for a lack of interaction. It can be difficult to predict how some sessions will be received, but this was very constructive feedback for the presenters who also felt they had learnt more about what works and what to do better next time.

In addition to the outcomes expected from this work, there were a number of other points. The Team achieved positive agreement from others to work together and share ideas, and the desire from a number of partners to build networks for future funding.

The Project Team has initiated a small follow-up study in conjunction with the UK Physical Sciences Subject Centre to see if the attendees of the events have adopted anything they experienced at the event or promised they would do in their feedback.

Overall the innovative blend of outreach in action and the parallel event for HE staff seems to have worked and was valued; a point reinforced by the informal feedback received on the day.

Sustainability

The publicly available case studies, available form the HE STEM and UK Physical Sciences Subject Centre websites, offer a longer-term legacy for this project. The case studies are written to encourage engagement and suggest ways in which HE staff can get involved in these projects for themselves.

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.

The Project Team note that having commitment and support on a strategic level from the senior management of the host institution matters greatly. 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.

Luggage Lab

Project Lead: Sean Ryan, School of Physics, Astronomy and Mathematics, University of Hertfordshire

Collaborating institutions: Institute of Physics; East of England Science Learning Centre

Abstract

Attracting students to study physics through Access to HE[1] is a national priority. Luggage Lab was designed to strengthen students' interest in and commitment to physics by exploiting their preference for practical activities.

A collaboration between the University of Hertfordshire (UH), the Institute of Physics (IoP) and the Science Learning Centre East of England (SLC-EoE) was set up. The aim of the group was to develop a set of self-contained and portable physics experiments and associated online resources to be used in school-linked outreach or loaned to schools. The experiments would bridge the transition from school to university physics and are intended to build students' interests in and engagement with physics as well as their understanding of the subject using equipment that is not commonly available.

This project was designed to build upon the Stimulating Physics Programme's teacher-support element.[2]

Background and Rationale

Physics is widely regarded as one of the more difficult subjects students take at school and university. As a result, a minority of students continue with physics to more advanced levels. It is often noted that students enjoy practical classes more than theoretical ones. Regrettably, with fewer schools having teachers with a physics degree, it becomes increasingly difficult for schools to select, provide and explain the significance of physics experiments. Increasing students' opportunities to encounter and conduct interesting experiments provides one means of supporting their learning and sustaining their engagement with physics. Consequently, increased engagement may result in students continuing to study physics to more advanced levels. Luggage Lab takes some of its inspiration from the successful IoP-operated project Lab in a Lorry[3], and has some parallels with the independently conceived Royal Society of Chemistry outreach activity, Spectroscopy in a Suitcase.[4]

The experiments and support materials are designed to include positive emphasis regarding gender and ethnic minorities. Furthermore, the project supports non-specialist teachers of physics who may lack the experience or confidence to develop and interpret advanced experiments. The experiments are supported by a website[5] that enables teachers and students to access historical information, procedural and safety instructions and examples of experimental analysis, before and after they conduct the experiments.

This project aligns with the strategic aim of the National HE STEM Programme for higher education engagement with schools and colleges.

Implementation

The initial aim of the project was to identify the scientific topics and themes that should be addressed. The selection of themes was mostly achieved through internal discussions. The Project Team held meetings with and tried to involve teachers in this selection process through local and national (for example, IoP) networks. While those who were consulted were very enthusiastic about the project, few concrete suggestions were proposed. The Project Lead believes this illustrates one of the problems that this project was seeking to address; which is that a lot of science teachers struggle to conceive of the activities they might undertake even if they had the necessary equipment.

In total, four themes were identified. The "resonance" theme was one which was proposed by teachers, and then the Team identified what might be done and how it could be implemented. The other three themes were all identified by the Project Team themselves to reflect what they believed would benefit students and teachers. The themes selected, and the experiments used were built on the idea of bridging the gap between A-levels

[1]For details, see: http://www.accesstohe.ac.uk/

[2]For details about the programme, see: http://www.stimulatingphysics.org/teacher-support.htm

[3]For details, see: http://www.labinalorry.org/

[4]For details, see: http://www.rsc.org/education/hestem/sias.asp

[5]The instructions for students that will appear on this website are currently being revised. The site will become available after this task has been completed

and university. The Team looked to pinpoint which concepts are key and which practical experiments could be undertaken, but which would not already be available in schools. Feedback from teachers during the pilot sessions suggests that the themes were well chosen.

One theme that the Project Team would like to have covered, and which other teachers mentioned too, was radioactive substances. However, this topic would be particularly difficult for health and safety reasons, and therefore not a sensible starting point.

In the end the Luggage Lab experiments were grouped into four themed packages with experiments to support each theme. These packages offer the possibility of teachers exploiting synergies between two or more experiments to create a sequence of activities to draw students into more advanced topics. The themes and experiments are:

- Resonance – resonances; mechanical; acoustic; electrical and atomic
- Wave-particle duality – optical diffraction; electron diffraction
- Energy from light – photoelectric effect and photovoltaics
- Speed of light – time delays; Michaelson interferometry and refractive indices

Evaluation

Five events were run to evaluate the Luggage Lab project.

- Public open night, Bayfordbury Observatory and Science Learning Centre
- University of Hertfordshire and AimHigher STEM Fair, University of Hertfordshire
- Science Additional Specialism Programme (SASP) teachers, SLC-EoE
- School visit to Highlands School, Enfield
- Big Bang STEM Fair, Duxford

Public Open Nights are a regular winter/spring event at the Bayfordbury Observatory and typically attract 400–500 visitors at each of four or five evenings. Visitors cover a wide age-range with a high proportion of school groups and community groups (for example, Brownies). Visitors were provided with access to the Michaelson interferometer, the wave-particle duality kit and the refractive index kit, each of which had a demonstrator in attendance.

Demonstrations and qualitative experiments took place for an audience of the general public, giving visitors an opportunity to interact with the experiments. These events were very popular and demonstration stands were very busy.

One student highlighted the key motivation for this project when they said "*I love science, but we don't get to do many experiments*".

The event held at the STEM fair was attended by a number of Hertfordshire secondary schools. Each school rotated around a subset of stands in 30-minute periods. Over the course of the day, ten schools visited the physics stand. Each visiting group typically consisted of 6–8 students accompanied by a teacher and a university guide. The students were given a quick qualitative demonstration of the wave-particle duality experiments and were guided through the process of making their own measurements of optical and electron diffraction patterns. Students were surveyed following the event. The majority of students found the Luggage Lab activity interesting.

Luggage Lab was permitted to take over an afternoon session of the SASP physics course. 16 existing teachers undergoing additional training in physics attended the session. The class was split into four groups, and each group undertook a single experiment. The teachers' confidence in dealing with experiments varied and those less confident would have struggled to conceive, develop and implement experiments such as those contained within Luggage Lab. For these teachers, Luggage Lab offers support and inspiration by providing selected equipment and experimental scripts for both closed and open-ended activities. Feedback from the SASP tutor was very complimentary and confirmed the worth of using Luggage Lab in schools.

"Luggage Lab has succeeded in making available self-contained, transportable experimental packs which enable students to undertake physics experiments using equipment not commonly available to them in schools, and which expose them to physics topics that go beyond A-level material, thus giving them a taste of the fascinating physics they can study at University."

Sean Ryan, School of Physics, Astronomy and Mathematics, University of Hertfordshire

Discussion

The Project Team believes that the Luggage Lab project has been very successful and has met all its original aims, developing a series of experiments and supporting materials for use by schools.

The commitment of effort from a physics laboratory technician on the development of the experiments, and the member of staff to assemble, integrate and test the packages was essential. The many voices of support for the project provided reassurance that the end users would welcome the completed project.

Initially, the Project Team took part in some unproductive consultations and, rather than press on with what were considered suitable experiments, the Team persevered and sought the views of school teachers through a number of routes involving the University of Hertfordshire, the IoP and the SLC-EoE. The response from teachers was enthusiastic but feedback was not particularly focused. Consequently, the Project Team went ahead with its ideas with very limited input from potential final users.

The Team also experienced heavy demands on their time. The progress in developing, testing and piloting the packages was slower than anticipated due to competing time demands of those individuals involved.

Sustainability

Luggage Lab has succeeded in making available self-contained, transportable experimental packs that enable students to undertake physics experiments using equipment not commonly available to them in schools. Students are exposed to physics topics that go beyond A-level material, giving them a taste of the fascinating physics they could study at university.

The experimental packages that have been developed are being made available to other users, for example, school teachers, through the SLC-EoE.[6] Users will need to cover their own transport costs but will not have to pay for the equipment itself. Once the Project Team has good supporting evidence of the equipment being used, they expect to apply for further grants from other bodies to extend the concept.

The Luggage Lab project is firmly based within physics activity, however it is easy to see how similar activities and events could be run for all other STEM subjects and the learning and best practice established during this project would be very useful to others interested in running similar programmes of activity. Obviously the physical equipment used by the Project Team can only go on to serve a small geographical region in the future; therefore there would also be benefit in duplicating the Luggage Lab itself for use in other areas.

In Luggage Lab, going out to consultation with teachers reassured the Project Team that the project's aims were laudable, but did not result in concrete input to the project. With the benefit of hindsight, the recommendation to others wishing to develop similar projects would be to trust your professional intuition and forge ahead with your project without feeling the need to seek further external input.

[6] The Project Team will make the link to these resources from their own website as soon as it is available

Enhancing the impact of chemistry outreach by use of selected, repeated interventions and collaborative university provision

Project Lead: Neil Williams, School of Pharmacy and Chemistry, Kingston University

Collaborating institutions: Imperial College London; University of Greenwich; Queen Mary, University of London

Abstract

The primary aim of this project was to organise and deliver an outreach activity to students who had already participated in an outreach activity on a previous occasion. Repeat and/or early interventions have been identified as a way to improve engagement of students who may be interested in pursuing a career in chemistry and may consequently have a positive effect on students' decisions to continue studying science. The event was to be run as a collaboration between a number of university chemistry departments across the London region.

Students' opinions of the events and their attitudes towards continuing their studies in chemistry would be evaluated fully following the second event and compared to evaluations received following the first event.

Background and Rationale

The evaluation reports of the Chemistry for our future[1] pilot project noted that the greatest impact of outreach events was for students who already had some interest in chemistry but remained undecided about future plans. Repeated and/or early interventions were identified as potentially having greater impact than a more general approach. Consequently, it was proposed that encouraging sustained outreach as a collaboration between university chemistry departments in the London region would help meet this need. This project involved organising an outreach event as a follow-on for year 10–11 students who had attended a previous summer school as year 9–10 students. The event would then be evaluated by the students to see what effect a repeat intervention had had on their desire to study chemistry, or a related STEM subject, in the future.

University chemistry departments in the London region (Imperial College London, University College London, Kingston University, University of Greenwich and Queen Mary, University of London) developed and delivered a wide range of school outreach events as part of the Chemistry: The Next Generation (CTNG) pilot project and its follow-on programme as part of the Chemistry for our future (CFOF) project. Generally, students participated in just one outreach event and this was often when they were already studying GCE A-level chemistry.

Emphasis was put on providing events for younger year 9–11 students during the CTNG project in the London region. Students at this early stage are still some way away from making career decisions and it is unlikely that a single outreach activity will influence decisions strongly. The CFOF evaluation report suggested that the greatest potential for impact seems to be with young students who are already thinking of studying for a career in science. Within this group of interested students, around 40% remain uncertain about pursuing this route. In addition, in response to chemistry outreach events, teachers report, "*whilst one-off activities provide a spark, more sustained activity is important to boost impacts and make a difference*". With this in mind, the Project Team were interested in holding a collaborative event for students as a follow-on for those who took part in a previous CFOF summer school event as year

[1] The Chemistry for our Future programme was a £3.25 million pilot project, funded by the Higher Education Funding Council for England between September 2006 and August 2008. The Royal Society of Chemistry managed the project. For more details, see: http://www.rsc.org/Education/CFOF/

9 students in 2009. An evaluation of the impact of a repeated intervention from a student's point of view would indicate if this was effective practice and worth developing further. The Yorkshire and Humber region have previously undertaken activity on repeated interventions and this project was expected to build on this work[2].

The National HE STEM Programme's strategy actively promotes engagement with schools and/or colleges with higher education institutions, which play a vital role in raising the aspirations of students and encouraging them to engage in further study. This project addresses this strategic aim directly. Furthermore, while this activity is chemistry-based, it is easy to envisage similar projects operating in all STEM disciplines or even across disciplines.

From the outset, it was acknowledged that a number of follow-on events would need to take place to provide a sufficiently large number of student responses to allow a proper and true evaluation to take place. A sufficiently large number of students are also needed to ensure that any impact resulting from follow-on events is not just confined to a single small group.

Implementation

The key contacts[3] for the project met in March 2011 at Imperial College London to arrange the programme and venue for the outreach activities. An outreach management service, Exscitec[4], was employed to co-ordinate the booking of venues, recruit students and oversee the event. Around 80 students who had attended a previous CFOF summer school in the past two years were contacted. Only 11 students from this cohort were willing and/or able to attend an additional event. An additional 30 students were recruited who had not been to a previous outreach activity.

The outreach activity day started in the morning with an introduction by speakers from Kingston University. The students were then split into three groups and taken to one of three possible workshop activities: Blue Printing, Glow Stick, and Nanoparticles[5] run by student ambassadors from Imperial College London, University of Greenwich, and University College London. The workshops ran for 1h 15mins. In the afternoon, the students attended a second workshop. The day concluded with a demonstration lecture from representatives from Queen Mary University of London before an evaluation and feedback session.

[2]For more details, please see the evaluation of Chemistry for our future, extension phase report, sections 2.3.2 and 2.3.4; http://www.rsc.org/Education/CFOF/

[3]The key contacts for this project included: Dr Neil Williams, Kingston University; Dr Jodie Kirk, Imperial College London; Professor John Nicholson, University of Greenwich; Dr Dewi Lewis, University College London; Dr Adrian Dobbs, Queen Mary University of London and Lucy Smith, Exscitec-Science Outreach Officer

[4]For details, see: http://www.exscitec.com/

[5]These existing workshop activities were developed by University College London, University of Greenwich and Imperial College London and, as such, are not publically available. Similar activities were developed as part of the Chemistry for our future project and are publicly available here http://www.rsc.org/education/hestem/outreach/

Evaluation

The event was based on a proven programme developed as part of the CFOF pilot project involving the five university chemistry departments from across the London region. Although time consuming, a meeting involving all collaborators was important to get everyone to agree upon the individual contributions. They also ensured a consensus on the structure of the day and the nature of the evaluation. Student recruitment, good communications with schools, and the smooth organisation of the event were assured by the management services of Exscitec.

The original aim of the project was to recruit at least 30 students to take part in the event who had previously attended an outreach event. However, serious problems were encountered when trying to release small numbers of students from school to take part. In an attempt to recruit more students who had attended a previous summer school, students who had attended outreach events two years ago were also contacted. Only 11 students were recruited to take part in the repeat intervention. This highlights the problem of targeting repeat interventions as it significantly reduces the pool from which recruitment is possible. In general there is a growing problem of extracting students from schools to attend off-site events and activities. In the future the Project Team may look into hosting the event at a school; this may make recruitment easier if suitably located.

Broadly, the evaluation indicated that such an event (as a repeat intervention) helps maintain students' interest in studying chemistry and had a similar impact on students' intentions for their future as the first intervention (in this case a summer school).

Discussion

Of all the students that took part, 55% stated they were more likely to study a science or engineering subject at university after attending a second outreach event and the other 45% said their view was unchanged. 44% stated they were more likely to study chemistry at university and 11% said they were less likely to study chemistry after attending the event. 60% of the same cohort indicated that the first event had made them more likely to study science and engineering at university.

The written feedback indicated that the initial three-day residential summer school, not surprisingly, had a greater impact on their outlook. Nonetheless, the students' comments indicated that the second event helped maintain their interest and also demonstrated different aspects and highlighted different options. The evaluation questionnaire also revealed that 55% of the students from this group were already considering studying chemistry or a chemistry-related subject at university before attending the summer school. Naturally, if many of the students that attend such events are already considering studying science and engineering then they may help to 'firm up' the students' ideas rather than radically changing minds, thus reducing the potential impact of such outreach activities. Overall, it is difficult to draw strong conclusions from this small sample, however, the general impression is that a repeat event does maintain the student's interest in science and engineering, but doesn't really change a student's plans dramatically.

A survey of all students attending the course (not just the repeat students) indicated that 86% were more motivated towards their studies, more likely to study science beyond GCSE and more likely to go to university after attending the event. Only 11% disagreed with the statement "*I am more likely to go to university after attending the event*". However, the impact on the likelihood of pursuing a STEM-related career was lower, only 35% of students said they were more likely to pursue a STEM-related career.

Although the impact of this single event has been small (which is, perhaps, not surprising given its small scale) it does provide some good learning for future events and for others seeking to undertake similar activities across any STEM subject.

Sustainability

No definitive conclusions can be drawn from a single event and evaluation. One of the major drawbacks associated with the approach of repeated interventions is recruiting the students to events outside of school. The Project Team believes repeated interventions are a good way of consolidating the work of expensive outreach activities such as summer schools, but arranging an event to which all the students can return is not feasible. Because the recruitment of students is one of the most frequently cited reasons which discourages academics from organising outreach activities at university, the hosting of repeated interventions must be considered with caution. However, should the decision to host a repeat intervention be taken, then the use of a third party, such as an outreach office, is to be recommended to assist with organisation.

This limited study does suggest repeated events are relatively effective because, in part, they are dealing with an already engaged audience. However, restricting an event to previous attendees is unlikely to be beneficial. Students who have not had the opportunity to attend events before should also be welcomed.

The Project Lead is confident that this activity will continue, albeit in a modified form. Other funding sources have been identified for the ongoing costs of the programme and a greater use of volunteers will be required. Use of a private school venue is one option for future events. Hosting at a private school should provide some funding to support additional students from widening participation backgrounds to attend, mirroring the aims of the National HE STEM Programme.

This project has encouraged the chemistry departments involved to continue running collaborative events and targeting students who may have attended events in previous years. It is noted that personnel and funding issues have prevented any further activities from taking place in 2011, but there is an intention of continuing these during 2012.

Repeat outreach activities for students is possible in all STEM subjects and the learning gained from this project can be transferred to other areas directly. It is also possible to envisage collaborations for repeat activities that focus upon encouraging students into STEM in general as opposed to just a single discipline.

Implementation of the University of Manchester School of Chemistry Practical Boot Camp at the University of Nottingham

Project Lead: Jonathan Agger, School of Chemistry, University of Manchester

Collaborating institutions: University of Nottingham

Abstract

The University of Manchester created the Practical Chemistry Boot Camp in 2007 as part of the Chemistry for our future programme.[1] The one-week course, based on the well-known chemistry of aspirin, was designed to restore student confidence in performing practical chemistry. The students typically displayed a range of competencies in practical skills, often dependent on the level of practical content of A-level syllabi.

The boot camp course is designed to provide students with a solid foundation in basic skills through fours days of experimentation and one day of report writing. Having run the course successfully for four years with glowing feedback from participants, the objective of this project was to successfully transfer the boot camp to The University of Nottingham.

Background and Rationale

Owing to differing A-level syllabi and differing levels of funding within schools and colleges, first-year undergraduate chemistry students arrive at university with widely varying competence in experimental practical skills. In response to this, and as part of the Chemistry for our future project, The University of Manchester Practical Chemistry Boot Camp was created in 2007. The boot camp provides an invaluable opportunity for students who have been accepted to study chemistry in England to experience a university laboratory environment in the run-up to starting their undergraduate degree programmes.

[1]The Chemistry for our future programme was a £3.25 million pilot project, funded by the Higher Education Funding Council for England between September 2006 and August 2008. The Royal Society of Chemistry managed the project. For more details, see: http://www.rsc.org/Education/CFOF/

The course is non-residential and free to attend although a small refundable deposit is charged to secure a placement. The students spend four days, in small groups working closely with a demonstrator. The students perform four experiments, in rotation, based on the chemistry of aspirin, which is hopefully familiar to the students. Each experiment is based within one of the four primary chemistry disciplines; organic, inorganic, physical and analytical. The experiments are:

- Organic: synthesis, purification and characterisation of aspirin
- Inorganic: synthesis of copper II aspirinate and salicylate
- Physical: kinetic study of the hydrolysis of acetyl salicylic acid
- Analytical: measuring percentage composition of aspirin tablets

Students are given examples of two different styles of report; a synthetic one and a measurement one and are required to prepare word-processed reports on the final day for two of the experiments they have performed. The demonstrators mark the students' reports and extensive feedback is provided. The students are provided with feedback questionnaires upon arrival at the boot camp and after completing the boot camp course.

The scheme has proved highly successful in terms of student feedback received and subsequent student monitoring of both performance in first-year laboratory class and student progression and retention to subsequent years. The purpose of this project was to successfully share and transfer practice of the boot camp to a partner institution, the University of Nottingham.

In preparation for the implementation of the boot camp at the University of Nottingham, Dr June McCombie attended the event run at the University of Manchester in September 2010 to observe and monitor the running of the camp. Dr McCombie was able to discuss all aspects of the camp with the University of Manchester organisers, demonstrators and participating students. All documentation pertaining to running the camp was then provided and a joint website was created to advertise and accept student registrations.[2] The boot camps were then advertised at UCAS events and through mail shots to UCAS lists and to schools in the local areas. The boot camp was then scheduled to run from late August to early September 2011 in Manchester with 22 participants and in early September in Nottingham with 20 participants.

Implementation

The boot camp is typically held around the last week of August and into the first week of September, starting on the Tuesday following the summer bank holiday. Obviously, the course must be timetabled to finish before term starts and scheduling the course to run after the Reading and Leeds music festivals enhances student participation.

The boot camp aims to achieve an informal learning environment where the students feel comfortable with the staff and the demonstrators and are hopefully not daunted by the experiments themselves — the choice to study the chemistry of aspirin is quite deliberate in this respect. For many of the students taking part, this course is their first taster of higher education. Consequently, the staff members make every effort to be friendly and approachable and the use of first names is recommended. Students are assigned a postgraduate demonstrator at the start of the course and work with that same demonstrator throughout the boot camp rotating through the four experiments and the report writing exercise.

The organisers at both of the participating universities have extensive experience of first-year laboratory classes and in delivering outreach activities, which helps ensure the teaching materials are pitched appropriately and helps to bridge the transition into university for the students. In addition, it is important to have a good working knowledge of the postgraduate demonstrators in the school and their skills. It is of paramount importance to select experienced demonstrators with a proven track record of dealing with undergraduate students well. The demonstrators must be thoroughly conversant with the experiments and they must actively teach the students correct experimental technique. Good communication skills are therefore considered vital. Ten students per postgraduate demonstrator group are recommended as the maximum. At the University of Manchester, the boot camp course is run with between two and three members of staff. Again, staff must be enthusiastic and willing to participate fully in the activity.

"Really enjoyed the week. Probably the best way to prepare for university practicals. Given me a lot more confidence and now I feel a lot less scared about going into the labs for real. Everybody was really helpful, friendly and understanding when we didn't know what we needed to do. Also a good opportunity to meet other new chemistry students, especially for those going to Manchester or Nottingham Universities. Overall, very useful and enjoyable. Thank you."

Student Participant, Chemistry Bootcamp

The students are provided with a detailed laboratory manual that guides them through the four experiments. The postgraduate demonstrators are provided with a demonstrator-version of the manual that contains analysis and results for each experiment. The experiments require fume cupboards, basic glassware and synthetic apparatus, thermostatically controlled water baths, UV/vis spectrometers and (ideally) access to an NMR facility. The chemicals involved are all readily available and not costly with the exception of over-the-counter aspirin tablets. Owing to recent changes in government legislation it is impossible to buy the quantities of aspirin tablets needed without prior agreement from a pharmacist and a formal letter requesting supplies from the university department. All of the particular information for set-up of the event forms part of the boot camp roll-out pack, the details for which are available on request from the Project Team.

Following the practical experiments the students are given guidance in correct procedures for writing both synthetic-style laboratory reports, with formulaic methodology and concise reporting of analysis, and for measurement-style laboratory reports, with detailed attention to presentation and analysis of data and drawing conclusions. The students are provided with example reports for similar experiments. Ideally, the practical course is scheduled from Tuesday to Friday inclusive. This gives the students the weekend to work on their reports if they wish prior to the actual report writing session on the Monday. This timing schedule was implemented following the suggestions received on student feedback forms during some of the first boot camps. The students are given until early afternoon on the last day to submit reports on two

[2] For details about the boot camp courses and to request an event roll-out pack, see: http://www.chemistry.manchester.ac.uk/bootcamp/

of their experiments. The postgraduate demonstrators then have two hours to review and provide feedback on the reports. In the meantime the students complete the boot camp questionnaire and, if resources permit, are provided with a Flash Bang Show demonstration lecture. A demonstration event is optional but encourages further engagement with the students. Feedback is returned to the students that afternoon, the questionnaires are collected and the course then officially ends.

The boot camp has run every year at the University of Manchester since 2007 and it makes use of the quiet undergraduate laboratories during the summer between other events and the preparation time for the forthcoming academic year.

"I found this invaluable. I have done no chemistry in the past few years and this has helped enormously. I have done HE chemistry before and I wish I had had this opportunity first time around. THANK YOU!!!"
Student Participant, Chemistry Bootcamp

Evaluation

The success of the boot camp is assessed through extensive student feedback using two questionnaires. The first short questionnaire is presented to the students as part of their induction and comprises six questions concerning perceived confidence to perform university practical work prior to attending the camp. The second questionnaire is far more detailed and comprises 40 questions. It asks the students to reconsider their situation after the camp and gathers data on the performance of the staff and the postgraduate demonstrators, perceptions of the individual experiments and general organisation of the camp. Finally the students are actively encouraged to write a short commentary.

In addition, undergraduate laboratory performance and retention rates of attendees that go on to study at the University of Manchester are monitored.

"I have really enjoyed the bootcamp and it has vastly improved my confidence in being able to perform university practical work. I am no longer terrified of starting university and am now looking forward to studying chemistry."
Student Participant, Chemistry Bootcamp

Discussion

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. Feedback in previous years has even indicated a small number of students were almost too anxious to attend even the boot camp.

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. The relatively small differences seen in student ratings for improvement in theoretical skills owes to the design of the course. 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.

The key enablers to success of the boot camp are to get enthusiastic staff members and good postgraduate demonstrators involved in the project because this boosts the learning experience of the participants immensely. The demonstrators must constantly adopt a proactive teaching role rather than a passive surveillance role as is sometimes unfortunately observed in undergraduate teaching laboratories.

Sustainability

Following the funding received from the National HESTEM programme the Project Team continues to seek additional funds through the Programme and also from other sources to run the camps in future years. All the necessary materials and documentation have been prepared to enable higher education institutions to readily set-up and run their own boot camps. The primary costs associated with this project are postgraduate demonstrator salaries and staff time.

The module in its current form is ready to roll out to other higher education institutions but future work could well involve creating a version of this project suitable for university physics departments.

Case Studies: Enhancing Delivery of the Higher Education Curriculum

Chemistry Practical Skills Podcasts: Videos to enhance the student experience of laboratory classes

Project Lead: Daniel Driscoll, Chemical Sciences, University of Surrey

Collaborating institutions: University of York

Abstract

The aim of this project was to prepare a series of video podcasts that demonstrate a variety of common techniques used in the chemistry laboratory. The Project Team aimed to produce a series of 5-minute videos, filmed and narrated by student demonstrators, to show common techniques and experiments. The videos would also be subtitled for the benefit of the hard of hearing. These videos would enable students to become familiar with new laboratory techniques before being expected to use them in practical sessions.

Background and Rationale

New undergraduate students often begin their chemistry laboratory classes without a clear understanding of the practical techniques or theory required. This is especially true if the students have had little or no practical chemistry experience during their A-level studies. This is often the case with those taking Bioscience programmes because they may not have studied chemistry at all. A lack of practical chemistry skills, and the theory behind them, is also increasingly common amongst those who have previously studied chemistry because many further education institutions are unable to offer adequate practical laboratory classes.

Experience tells us that it is often only during the final report write-ups after the practical session has ended that students start to focus on what the practical learning objectives were, and there is evidence that students would benefit if they were already familiar with the techniques and theory before entering the laboratory.

Chemistry departments at several higher education institutions (for example, the University of Bath, Bristol University, the University of Nottingham and the University of Warwick) use videos in pre-laboratory preparation exercises to promote student familiarity with new techniques and apparatus.[1] One of the contributors for this project was heavily involved in the production of videos at the University of Warwick and anecdotal evidence shows that students who have viewed such videos before entering the laboratory are more confident when handling apparatus. Furthermore, questions asked of the demonstrators or technical staff by students who have viewed the videos in advance tend to be focused on the learning objectives and less on the technical details of the class. It was also found that problems encountered by students using new and unfamiliar equipment were minimised, which enabled teaching staff to spend more time addressing students' scientific understanding of each experiment.

It has been reported by Burewicz and Miranowicz that, "the use of varied forms of visualisations of chemical and ecological questions distinctly raises the effectiveness of teaching".[2] They describe how the use of various visualisation tools, including video, leads to improvements in the students' understanding, recall and motivation in class. Bunzli et al. also reported the advantage of using videos of experiments to illustrate the main principles and phenomena described in their teaching programme.[3]

Most higher education institutions are increasingly using e-learning resources because they are an effective way of reaching a wider range of students and improving the learning opportunities available to them.

The Project Team aimed to make the videos available to all members of the university through the University of Surrey's e-learning portal (uLearn); the videos should be of use to anyone who has a practical chemistry aspect to their studies or research

[1] For details of a similar project also funded by the National HE STEM Programme, see Case Study 20 of this report

[2] A. Burewicz, N. Miranowicz, Categorization of visualization tools in aspects of chemical research and education. Int. J. Quantum Chem., 2002, 88, 549–563

[3] J.-C. Bünzli, E. Fernandes, D. Imbert, A.-S. Chauvin, F. Emmenegger, C. Rauzy, C. Piguet, N. Ouali, S. Koeller, G. Süss-Fink, F. Chérioux, General Chemistry for Students Enrolled in a Life Sciences Curriculum. Chimia, 2003, 57, 99–104

including disciplines such as chemistry, materials science, engineering, biosciences and physics.

The main aim was to produce videos that show chemistry-based techniques and to evaluate their use by, and usefulness to, students. The Project Team proposed three strategies to assess this:

- By recording the number of times each video was accessed through the university's e-learning suite
- Before starting laboratory sessions, students would be asked to complete a short online quiz for each experiment based on the videos and other pre-session information. This would allow the effectiveness of the resource to be monitored before the laboratory session
- Assessment forms are currently routinely handed out at the end of every module across the various disciplines. Extra questions would be added to the laboratory module forms to include, for example:
  - Rate the videos: did they improve your understanding of the practical?
  - Which video or videos were most useful?
  - Which video or videos were least useful?
  - Please give any comments that would help improve the resource

This third form of evaluation has the advantage that it comes directly from the students and would allow the Project Team to monitor progress after laboratory sessions, which would also point to improvements that could be tailored to student needs.

Feedback could also be sought from academic staff, postgraduate demonstrators and laboratory support staff on the following issues:

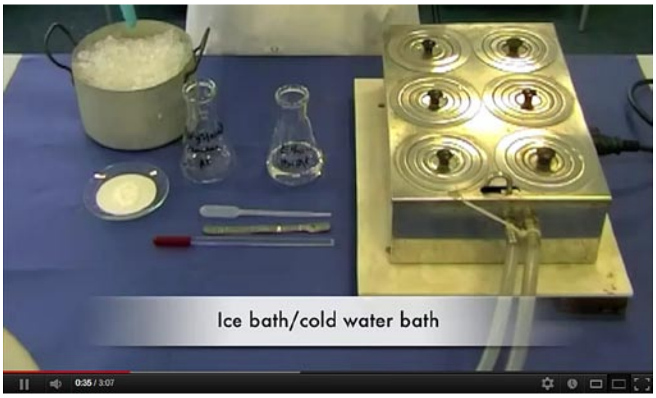
- Did the sessions run more smoothly than previous years?
- Did you notice a change in the type of questions that the students asked (i.e., were they more chemistry related rather than "How do I do this?")?
- What could be improved for next year?

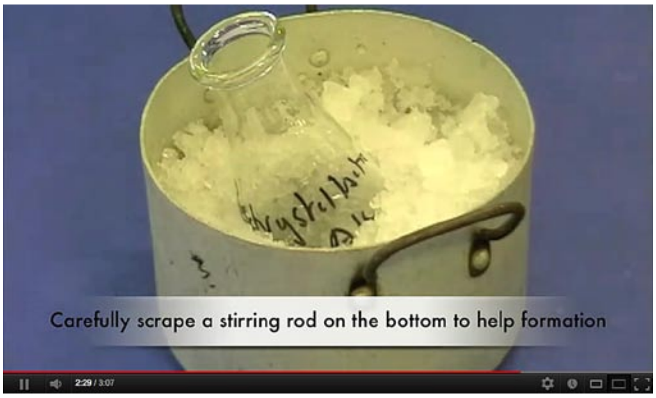
Implementation

Before the instructional videos could be produced, the Team needed to recruit further people to contribute their ideas who would also be prepared to evaluate and critique the work of the Project Team. Students then needed to be recruited to test run the resources and provide feedback to the Team. In all, 16 members of academic staff, 6 members of technical staff and over 100 students were involved.

Following production, the completed videos were made available for level-1 students to view through the university's virtual learning environment. The videos were then available to the next intake of students to view from the start of the academic year and before practical sessions began in late November.

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. Many other institutions report considerable success and the Team are very hopeful that they will see a similar response.





Evaluation

The Project Team believes that they have successfully met the aims and objectives of this project. However, due to the nature of this project, the Team are not able to provide a detailed assessment of the impact that this project has had. The Project Team needed to allow the resource to be used by current level-1 students and feedback to be gathered after their laboratory sessions. It has taken some time for student uptake of these resources to gain momentum and, to date, the resources have not been well used. The Project Lead continues to encourage academic staff to point their students in the direction of the videos as preparation for their classes. The students that have used the resources have reported that they have found them useful.

Evidence of success to date is that 17 instructional videos have been produced; this number is more than the 14 videos that the Team originally planned for. Topics covered are:

- The use of autopipettes
- The use of bulb pipettes
- The correct use of analytical balances
- The correct use of Bunsen burners
- How to set up and use a burette
- How to perform a titration
- How to set up a distillation
- How to set up a reflux
- How to set up and perform filtrations
- How to prepare a sample for FT-IR analysis
- How to perform a liquid-liquid extraction
- How to use melting point apparatus
- How to use a rotary evaporator
- How to perform a recrystallization
- How to prepare a standard solution from a liquid
- How to prepare a standard solution from a solid
- How to perform a TLC analysis

The resource as a whole has been viewed and critiqued by several academic members of staff and the technical staff who will be involved in running the laboratory classes. This critique process was carried out both during and after production to ensure good quality throughout. The techniques covered are explained in a clear manner and should be accessible to anyone with a scientific background. The Team provided on-screen subtitles and voice-overs to increase the accessibility to those students for whom English may not be a first language or those with disabilities.

Discussion

Creating the resource was made possible through the co-operation of the University's Centre for Educational and Academic Development[4] who provided cameras and video editing support, and the technical support staff from the chemistry teaching laboratory. The videos are hosted (in-house) on the university network and will be linked to through the National HE STEM Programme for the benefit of other institutions. The Team also plans to include the videos on the university's planned YouTube U site.[5] The Project Lead has requested for the videos made as part of this project to be added and is waiting for this work to be completed.

The Team feels that implementation of this project ran very smoothly and that all parts of the university and staff involved were very accommodating and cooperative.

Sustainability

While this project has achieved a good deal, the Team is unsure as to whether or not the project has had a large impact. The Team are unable to directly assess, through monitoring downloads/access, how much the resources are used because this information is not available to them through the university's virtual learning environment. However, they will continue to ask the students what they thought of the videos and if they found them useful. This will enable them to make any adjustments or improvements that may be deemed useful.

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. This project, as yet, has not influenced the practice of other members of staff with its own videos within the department or faculty, but all members of academic staff are being strongly urged to promote and encourage the use of the videos before practical sessions to help their students become familiar with techniques.

Pleasingly, the project will continue now in its current form. All of the video resources are hosted on the university servers and are freely available to all students. There are no ongoing costs (to the project) required to maintain this resource. There may also be the opportunity to expand on the range of videos available as part of unpaid work experience or project work for several students.

The Team are keen to encourage others interested in undertaking similar projects and offer the following advice. This sort of project is relatively easy to implement provided you have good technical support, good-quality enthusiastic students to do the videoing/editing/commentary and a suitable online learning environment.

[4] To learn more about the work of the Centre for Educational and Academic Development at the University of Surrey, see: http://www2.surrey.ac.uk/cead/

[5] To visit the University of Surrey's YouTube U site, see: http://www.youtube.com/user/UniversityofSurrey/featured

E-learning and formative in-course assessment in mathematics and statistics for engineers

Project Lead: Bill Foster, School of Mathematics and Statistics, Newcastle University

Abstract

This project was designed to extend the use of online practice and formative continuous computer-based assessment (CBA) in mathematics and mathematically based subjects for first year students in the Schools of Engineering at Newcastle University. The project was designed as an extension of the existing and proven e-learning and in-course assessment used in the School of Mathematics and Statistics.

The primary aim of the project was to develop online tests, questions and materials suitable for engineering students. The expertise, training and advice on authoring questions and tests was provided by the School of Mathematics and Statistics with input from subject experts in the relevant engineering schools. The School of Mathematics and Statistics agreed to supply the necessary infrastructure, access to the CBA system and to to host the question database initially for the Schools of Engineering. The Project Team wanted to produce generic e-learning and e-assessment material useful in all engineering disciplines and in a format which gave good and timely feedback where necessary.

Three modules were chosen for this first phase: one module in mathematics taken by students from all engineering schools and two modules from the School of Mechanical and Systems Engineering and the School of Civil Engineering and Geosciences.

Background and Rationale

The Project Team wanted to provide first year undergraduate students in engineering with increased opportunities for relevant and challenging practice and formative feedback in essential skills in mathematics and statistics linked to their disciplines. After providing these opportunities the Team were keen to go on to promote and embed the use of these proven e-learning techniques in other STEM disciplines at the university and to introduce staff in these other disciplines to these techniques.

This project fits in neatly with the National HE STEM Programme strategic aim to support enhancements in the curriculum for students.

Implementation

The project began with the Project Lead training a domain expert, Dr Andreas Kontaxis from the School of Mechanical and Systems Engineering, in using the i-assess software. Dr Kontaxis subsequently produced the first versions of two of the engineering specific question databases in mechanics and thermofluids. These questions were in the general topic areas of number representation, and units and dimensions underpinning these and other courses in engineering.

A review, testing and validation phase followed this development phase, which was undertaken by Dr Sandy Anderson from the School of Mechanical and Systems Engineering. The changes suggested as a result of the evaluation were carried out by the Project Lead in conjunction with Dr Kontaxis and further reviewed by Dr Anderson. At this point Dr Kontaxis left the project.

At this time it was decided:

- To create videos to include in the mechanics and thermofluids e-assessment packages in keeping with their formative nature. Dr Sandy Anderson and another member of staff made 5 videos with minor assistance from staff in the School of Mathematics and Statistics[1]

[1]For available videos, see: Dimensions in formulae – http://player.vimeo.com/video/15361045; Presenting numbers in various forms – http://player.vimeo.com/video/15361347; Converting units – http://player.vimeo.com/video/15361613; Intensive and Extensive Dimensions –http://player.vimeo.com/video/15361821 and Internal and External Dimensions –http://player.vimeo.com/video/15361973

- To include an e-assessment package for the Finance for Engineers course because this lends itself to learning by formative e-assessment and is general material common to most engineering project work. The material for this course was also provided and developed Dr Anderson
- To tailor a remedial maths and revision formative e-assessment for Stage 0 students. This also included videos created by Professor Robin Johnson from the School of Mechanical and Systems Engineering and the Project Lead for the Helping Engineers Learn Mathematics project.[2] This took the form of two e-learning packages. The mathematical material for these came from Dr John Appleby from the School of Mechanical and Systems Engineering and the Project Lead
- To prepare a formative e-assessment for revision of the Stage 1 first semester Engineering Mathematics course

Evaluation

An initial aim of this project was to increase student engagement in the relevant modules following on from the outcomes observed in the School of Mathematics and Statistics and the Business School at Newcastle University. This outcome has been tested and evaluated with students enrolled on the Science Foundation course and the levels of engagement for the in-course assessment increased significantly after the introduction of e-assessment.

However, for logistical reasons, this project has not yet been tested with the large student cohort currently enrolled and taking the engineering maths course. A trial for this project is planned for the second semester of the 2011–2012 academic year.

The Project Lead feels however that a number of very positive outcomes have already resulted from this project. This project has:

- Demonstrated that it is possible to set up resource-efficient continuous monitoring of students enrolled in large classes and provide them with relevant and timely feedback in mathematically based modules in STEM disciplines
- Achieved the additional aim, developed during the project, to supply engineering students entering their second year at the Singapore Campus[3] with mathematics material based around the e-assessment tool in a format suitable for distance learning. This material is in the form of a DVD and will be available to all 170 students in the coming academic year. Following the first year of implementation the material will be evaluated and modified as required for the following year's intake of students through internal university funding
- Modified the DVD material produced to provide a variant suitable for use by students entering with a non-standard maths qualification
- Four additional formative e-learning question databases have been prepared for revision and remedial purposes for first year engineering students in:
  - Basic maths
  - Basic calculus
  - A finance course
  - Engineering mathematics course

[2]For details of this project, see: http://www.lboro.ac.uk/research/helm/

[3]For details about the courses offered in Singapore, see: http://www.ncl.ac.uk/mech/international/

"The National HE STEM Programme awards have been crucial in giving the opportunity to spread successful and innovative use of e-learning within our university and to give a spring-board to develop further projects in this area benefiting the HE STEM community."

Bill Foster, School of Mathematics and Statistics, Newcastle University

Discussion

The major impact of this project is the uptake of e-assessment formative learning and assessment tools by the engineering schools following on from the demonstration of its efficacy both in the School of Mathematics and Statistics and also in the Science Foundation Year. The main evidence for adoption can be measured in terms of engagement levels, which have increased to over 90% on average for those completing the in-course assessment. Furthermore, feedback from students has been very positive. There is also anecdotal evidence of increased retention of students from the School of Mathematics and Statistics, but true evidence of this effect is difficult to disentangle from any general effects within the student cohort.

The main rollout for this project is planned for the next cycle of the engineering maths course, which is used by all 6 schools of engineering. Successful adoption of this system would signify a major change of tack for engineers at the university.

From an institutional point of view, this project, alongside other related projects, has generated a lot of interest in the use of formative e-assessment in the university and these projects have been reported on, to various university bodies and committees, and used as examples of efficacy.

In order to disseminate the outcomes of the project, and given various technical developments in the School of Mathematics and Statistics, it was decided that all of the e-assessment/learning packages outlined above should be converted into SCORM objects[4] thus enabling dissemination to all other higher education institutions in the following ways:

- Through the internet using direct links using the server at Newcastle University[5]
- Through the learning management system, Moodle, running on a virtual server at Newcastle
- By supplying DVDs or CD ROMs. The assessment system can run as a stand-alone programme using a web browser
- By supplying higher education institutions with zip files of the packages so that they can choose their own method of implementation

The work for this conversion was carried out within the School of Mathematics and Statistics by the IT team. This technical work was part of another larger internal project, from which this project greatly benefiting from the development work. Tailoring the conversion for the databases required a significant amount of time and effort.

Sustainability

Sustainability of the project at a local level is built into the project itself. The e-learning and e-assessment programmes and the tools will continue to be used as an integral part of the curriculum. Similar tools have been used in the School of Mathematics and Statistics for the past five years. This project has been crucial in demonstrating its application, efficacy and impact to the engineers. Colleagues from the School of Electrical, Electronic and Computer Engineering, the School of Chemical Engineering and Advanced Materials as well as from the School of Mathematics and Statistics are looking at adopting similar systems. Colleagues from a further 20 higher education institutions have also become involved through other similar projects.

The outcomes from this project were shared at two workshops held at Newcastle University.[6] The best practice developed as part of this project could easily be applied to other higher education institutions, allowing straightforward assessment of all students enrolled on maths-based courses.

The Project Team is also working on other projects in this area. For example, the National HE STEM Programme project on Integrating Formative and Summative E-assessment in collaboration with the University of Leicester and the University of Nottingham. Other groups within the HE community have also been formed to further extend, promote and disseminate this work. Finally, the Team have applied for JISC funding to create large-scale maths and statistics open educational resources for all STEM disciplines.

As noted above, there is now a lot of activity at Newcastle University surrounding the use of e-learning and e-assessment and the use has spread from the School of Mathematics and Statistics via this project to the Schools of Engineering. Furthermore, given the success in mathematics the university has funded the development of an open-source e-assessment tool, Numbas[7], that is being used in place of the original system, i-assess.[8] There are now discussions on this project being further financed by the University because it is one of the most advanced open-educational resources extant for mathematics and statistics, although the school itself will at the very least sustain it.

[4]For more details on what SCORM is and how it can be used, see: http://scorm.com/

[5]For details, see: http://varzi.ncl.ac.uk/

[6]The first workshop was held at the end of January 2011. The workshop was run by Dr Foster and Dr Anderson for engineering staff. The second workshop was held in February 2011 as part of the QuILT Teaching and Learning Seminar series to all University staff

[7]For details on Numbas, see: http://www.ncl.ac.uk/maths/numbas/

[8]For details on the assessment system, i-assess, see: http://www.ncl.ac.uk/maths/outreach/elearning/recent.htm

The transition into engineering: Scoping diagnostics and support tools

Project Lead: Peter Goodhew, School of Engineering, University of Liverpool

Collaborating institutions: Cogent Sector Skills Council; Liverpool John Moores University; University of Bolton; Queen's University, Belfast

Abstract

The University of Liverpool, in collaboration with some of its UK partners in the Conceiving-Designing-Implementing-Operating (CDIO) initiative[1], has developed a diagnostic tool for assessing the knowledge and experience of incoming engineering students. This tool, an interactive questionnaire, was focused on entrants with conventional (A-level) backgrounds. This project sought to extend this tool for applicants entering engineering courses through less conventional routes, for example diploma, apprenticeships, and workforce development programmes.

The benefit of this tool would be that higher education institutions could quickly identify areas of practical and academic strengths and weaknesses. Such knowledge could enable good support for new students entering onto engineering programmes and enable academic staff to understand better the abilities of the new student group and adapt the content and emphasis of first-year teaching accordingly.

Background and Rationale

The project arose from the perception of two of the partners (University of Liverpool and Queen's University, Belfast) that it would be extremely useful in delivering and improving first-year undergraduate engineering modules if the lecturing staff could be given a clear profile of the knowledge and understanding of the incoming student cohort. Such knowledge and understanding is not well captured by prior qualifications such as A-levels; whereas a detailed picture of technical understanding, practical skills and a general understanding of the societal context in which engineering is being taught would be very informative. As a result, these two partners had started to develop a modest paper-based questionnaire.

The overall aim of this first-phase project was to scope the necessary content for a set of web-based diagnostic and support tools designed to identify clearly the attributes and abilities of students entering engineering programmes and to support their transition into university.

The objectives and outcomes of the project were:

- To extend the content of the diagnostic test to include skills and know-how which might be appropriate to entrants from non-conventional (e.g. apprentice, diploma or further education) backgrounds
- To develop, with the Cogent Sector Skills Council, an interactive and online questionnaire and provide robust analysis of the results
- To identify support materials to fill any gaps in the knowledge identified
- To trial the diagnostic test and some of the support material with first-year engineering students at the University of Liverpool, Liverpool John Moores University, Queen's University, Belfast and the University of Bolton
- To trial the diagnostic test and support material with the first cohort of employees entering the Working Higher Foundation Degree in Nuclear Engineering
- To select examples of typical entrants, sharing the diagnostic results between the current partners, with CDIO partners nationwide, and with members of the National HE STEM Programme
- To ensure good working practice in the delivery of the online (open and free) diagnostic test with links to supporting resources

Implementation

The implementation of the project comprised four phases: development of the questionnaire; development of the delivery environment for the online test; delivery of the tests to the students, and analysis of the data collected.

The topics to be covered in the questionnaire were agreed at plenary meetings of the Project Team as:

[1]For details about the Conceiving-Designing-Implementing-Operating initiative, see: www.cdio.org

- Chemistry
- Energy – kinetic and potential
- The Workshop
- Nuclear Power
- How they work – mechanical parts
- General knowledge – environmental, evolution and biology
- Electronics and optics
- Office IT
- General physics – forces and motion
- General engineering – loads and gravity
- Materials properties
- Maths – trigonometry, binary and equations

Approximately 70 questions were written, of which 50 were used in the questionnaire. The criteria for good questions were to: use an appropriate vocabulary and style; provide unambiguous multiple-choice questions that each addressed a single concept or idea; contain answer choices which would unearth common misconceptions; and be culturally and linguistically neutral. A "not sure" option was also included in as many questions as possible, to emphasize that students were not being "marked" on their work.

When designing the delivery environment for the questionnaire, the Team reviewed a number of pieces of commercial software, including those available to Cogent, and those within the virtual learning environments of the partner institutions (principally Blackboard and Moodle). None of these were found to offer the required flexibility in delivery (i.e. to any student anywhere) or in data collection and analysis. Consequently, the majority of the project's staffing funds were spent on developing a web-based questionnaire system. The system now offers almost any type of question (including graphics if required) and enables the output of the raw data in spreadsheet format. The data input by the student, prior to answering the questions, comprises:

- Host institution
- Programme of study
- Highest qualification held [A-levels, Apprenticeship, Baccalaureate, Foundation Year, NVQ, SQA Advanced Highers, SQA Highers, Other]
- Nationality [UK, EU, Other]
- Email address [for response and feedback]

All of the partner institutions chose to deliver the questionnaires during week two of the semester, when students would have completed their registration and have email and web access. Most questionnaires were delivered in the context of a first-year study skills or core-skills module. Response rates were better when the exercise was carried out in a timetabled class session (for example, 112 completed questionnaires from a possible 154 students at Queen's University, Belfast) and lower when the students were told about the exercise and asked to do it later (for example, 93 completed questionnaires from a possible 270 at the University of Liverpool).

Unfortunately, it did not prove possible to implement the automatic email to each student containing feedback on his or her performance. The feedback should highlight gaps in knowledge, understanding and experience and point students towards learning resources to help them improve. It was therefore a priority to ensure that this feedback system was implemented.

For the same reason, and because it is difficult to find support resources at the appropriate level, support was not offered individually to students. However there are a number of general sites that offer explanations[2].

All the data, from a total of 312 students, was available in a single spreadsheet. Partners from the individual universities downloaded data for their own students and are using it in different ways. In addition, some of the data has been analysed centrally. So far, the following has been looked into:

- Correct answers to each question at university level (i.e. one set per university) and in aggregate (sum of all four universities)
- "Not-sure" answers to each question at university and aggregate levels
- Correct answers per question-group at university and aggregate levels

The aggregate data still needs to be analysed for the following:

- Programme of study
- Prior qualification
- Nationality

This remains a high priority for further work, ideally before the questionnaire is used again, however the analysis tool requires further technical development for this to be possible.

Evaluation

An interactive online questionnaire was developed for students entering onto engineering programmes. This diagnostic test allows evaluation of the understanding and abilities of students entering onto programmes. The questionnaire has proved very successful and the delivery process is working well. The diagnostic test and some of the support materials were trialled with first-year engineering students at the four partner institutions.

[2]For support resources, see: www.mathcentre.ac.uk; www.howstuffworks.com; www.raeng.org.uk/education/diploma/maths/default.htm; http://sls.uwe.ac.uk/ls/orgchem/

Although the design and implementation of the core questionnaire has been completed, a couple of points still require development. One such point was to scope the content of, and sources for, support material to fill the gaps identified in students' knowledge. There was insufficient time to develop this. Instead, students were directed to general resources to assist with their learning.

The results of the questionnaires were shared with the current partners, with CDIO partners nationwide, and with members of the National HE STEM Programme.

Discussion

The Project Team is confident that the questionnaire will continue to be used and developed so that more students can benefit during their transition to university[3].

The Project Team feels that they were somewhat overambitious in determining the amount of work that could be achieved during the timeframe of the project, and that further development is required. The key barriers to success and on-time delivery were:

- Difficulty in writing good questions – tuning the questions took a great deal of meeting time
- Restriction of the questionnaire time to one hour. The time required was over-estimated, and more questions could be added. However the restriction of time still means that each topic can only be explored briefly – essentially sampling a students' knowledge
- Delivery to students is best suited to a scheduled session
- Difficulty of delivering tailored support to every student. With the benefit of hindsight this was never likely to be achieved and would be a considerable undertaking[4]
- Some students gave fake email addresses, indicating that (despite efforts to persuade them otherwise) they treated the questionnaire as an assessment and were concerned about the results being used against them

The key indicator of success is that all partners are enthusiastic about using the questionnaire in future years following some revision and fine-tuning. Although each partner needs to interpret the data obtained for their own students, there are some overall conclusions that can be drawn:

- There is a wide range of highs and lows in student understanding across all topics
- There is a large degree of similarity between the student groups from the four universities, with only the Bolton students demonstrating a significantly different pattern of knowledge in some areas
- Only five of the 50 questions were answered correctly by more than 90% of all students. After debate it was agreed that there is value in retaining these questions for two reasons: they help give the students confidence, and they should be useful as a check that key topics remain well understood over the next few years
- Many students learn about topics that are not directly taught to them. However understanding is lower of topics which might be regarded as scientific or engineering "general knowledge" (e.g. evolution, nuclear power, photosynthesis)
- On average only 6% of responses were "not sure", and these were largely clustered around 8 questions, helping to identify areas that are less well understood
- Only 8 questions were answered correctly by fewer than a third of the students. The topics of these questions ranged across almost all topic areas, including chemistry, physics (mechanics), materials general knowledge and mathematics. These are the most important general gaps in knowledge that should be brought to the attention of staff teaching first-year students

Sustainability

The continuous involvement of technically-competent discipline-based specialists has contributed to the writing of sound accessible questions and the categorisation of topics for useful data analysis. Since the end of the original project, several students were employed to review and improve the question database. There are currently 80 questions, and 40 of them are used for the diagnostic test for first year students. Furthermore, new software has been developed to provide students with feedback[5]. The feedback to each question provides them with an explanation of the answer, plus the relevance of the topic to engineering curricula.

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[6]. 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.

It is easy to envisage similar diagnostic tools being developed for all areas of STEM and for students entering onto a range of courses at a range of differing levels.

[3]The support of software developers Liam Comerford and John Connor is gratefully acknowledged

[4]Pearson has spent millions developing good feedback for assessment questions (e.g. in Mastering Engineering) and still only covers a fraction of the ground being surveyed. For more details, see: http://www.pearsoned.co.uk/

[5]The developed feedback software was first run successfully with first year students at a number of collaborating universities in October 2011. The feedback itself was written by undergraduate engineering students employed over the summer break 2011

[6]Aston University and University of Strathclyde were early adopters of the questionnaire following the end of the original project. Two further universities are currently in talks with the Project Team with a view to also adopting the questionnaire for use in their institutions

SMART: Supporting MATLAB automated assessment to reinforce teaching

Project Lead: Alan Irving, Department of Mathematical Sciences, University of Liverpool and Adam Crawford, engCETL, Loughborough University

Collaborating institutions: Loughborough University; Institute of Mathematics and its Application

Abstract

The Department of Mathematical Sciences at the University of Liverpool wanted to set up a new computational methods module to apply various mathematical methods to problems encountered in engineering analysis using the industry standard programming environment MATrix LABoratory (MATLAB).[1] An estimated 250 students would use the module each year. The department wished to maintain high teaching standards by setting regular coursework which involves hands-on programming experience and provides regular timely feedback as feed-forward (where students learn from their assessment and improve their programming before the next submission).

The Project Team aimed to adopt a system developed by Loughborough University to automate the marking of students' MATLAB scripts and provide timely and individual feedback. This system is already used successfully in three engineering departments in Loughborough and makes feasible individual feedback to large cohorts of students in a much shorter time than would otherwise be possible.

Background and Rationale

The need for the project arose when the Department of Mathematical Sciences was given the task of training up to 300 second-year engineering students in numerical analysis and programming in MATLAB. Limited manpower resources for assessment and feedback were available. In particular, students hoped to receive feedback on their work before their next assessment was due so that they could improve and learn prior to their next submission.

[1]For details, see: http://www.mathworks.co.uk/products/matlab/index.html

Previous programming training had been provided in a piecemeal fashion across a variety of engineering modules, none of which were able to provide a systematic approach to learning MATLAB, assessment and feedback. Collusion had also been a problem. The learning and teaching aim was to have a more concentrated and integrated attempt to teaching numerical analysis and programming and to use the automated assessment system to provide regular individual feedback and marks in a time-limited class-test environment.

Implementation

The programming code developed at Loughborough University was re-organised making it more generic and easier for the user to identify which parts of the code (itself written in MATLAB) require altering for each application. Documentation, in the form of a 'tool kit', has been developed to guide the user through the practical aspects of this process and to explain how to implement the system using a virtual learning environment (VLE: based on Blackboard at the University of Liverpool and Moodle at Loughborough University).

The particular context at Liverpool was a time-limited (2 hour) class test, but the code can be applied to any electronically submitted assignment or programming project whose final product can be put in the form of a Function MATLAB File (FMF). Basically, the assessment code checks whether the submitted FMF runs and, if it does, tests the requested output against a correct answer. It is possible to anticipate and feedback on common errors. For each application, some effort is therefore required to design the relevant checks and an associated marking scheme. The latter can reward appropriate protection in the submitted code for improper input parameters.

The results are made available via the VLE and web. Details of total marks and individual feedback files are anonymous. Useful marking details and summaries are also provided for the tutor to assist with assembling general feedback based on the full set of submissions for the whole class.

An additional facility enables the tutor to convert the marking script (by simply changing one flag) into a version that students can use to get pre-submission feedback on how well their code is doing against the final marking criteria. This is an important aid when developing and testing prior to final submission. In particular, this can prevent the student performing blind submission of code that will fail owing to a simple programming error.

Programming code has also been developed that compares the active portions of all submitted code files to check for collusion. It assigns a numerical correlation coefficient to similar pairs of files and then, where necessary, collects these into groups that exhibit common coding that can then be further investigated.

An important aspect of the project was to develop the system further and enhance its portability thus facilitating its wider use in other modules and disciplines where MATLAB programming is a key element. Good progress was made in exporting the system and making it more easily adapted. Software to sift out groups of submitted work that showed evidence of collusion is included. The reaction from students at the University of Liverpool was mixed; highlighting the need for students to achieve a more than minimal level of programming competence before being able to benefit properly from the automated feedback system.

Evaluation

All of the key aims of this project have been met.

- Effective practice in assessing large cohorts has been transferred to the University of Liverpool, resulting in short marking times for scripts
- Lessons learned were fed back to Liverpool and programming code updated so that processes could be improved leading to further efficiencies in the marking of scripts and improved plagiarism detection
- A model of implementation that can be used across STEM disciplines has been developed

Each assignment was checked by at least two people to pick up any obvious errors in programming or in the student guidance notes. A wiki-style site for contributors to the module was set up to facilitate the checking and updating of software.

Formal student questionnaires were used at different points in the module. A module blog on the VLE at Liverpool was also maintained to monitor student concerns.

Discussion

The National HE STEM Programme grant has allowed a considerable amount of work to be done on the VLE implementation and for time to be spent on testing code as it was being developed. Comparison of experience at Liverpool and at Loughborough was particularly valuable. Both the Department of Mathematical Science and the School of Engineering at the University of Liverpool have provided teaching assistants who have helped staff during the training/practical sessions. The largest single enabler for this project was the staff time of the Project Lead and the pre-project development time by the Loughborough University.

"This grant has enabled our department to take on the teaching and assessment of a very large cohort of students which would not otherwise have been possible."

Alan Irving, Department of Mathematical Sciences, University of Liverpool

Because none of the teaching assistants were involved in the assessment of work or running of the assessment itself, this resulted in a reduced requirement for manpower for the assessment. That is to say that only one member of staff is needed to deal with all 250 submissions from students. The expertise and interpersonal skills of Dr Hughes were invaluable in managing the ongoing support and new developments from the Liverpool Blackboard team, ensuring the VLE interface worked well for both staff and students.

During the first application at Liverpool, the time students needed to move from using simple command lines of MATLAB to grasping the ideas of programming and, in particular, the need to understand the concept of a subroutine or function was greatly underestimated.

The deliberate strategy of the Project Team to teach numerical mathematics and programming in an engineering context all at once was overly ambitious. The syllabus and strategy had been planned in consultation with the client department but this approach has proved to be too complex and confusing for the weaker students. Previous implementations at Loughborough had, in part, overcome this barrier by integrating more training in MATLAB prior to using the assessment system.

Sustainability

The Project Team firmly believes that this project has had a broad impact at the institutions involved with this work. The future test for this project will be to see how many other institutions establish similar projects.

Some interest has already been received from academics at several other institutions keen to learn more about this project. The Project Team has also taken part in a number of dissemination activities. A Special Interest Group in 'MATLAB Learning, Teaching and Assessment' has been set up under the auspices of the Higher Education Academy Engineering Subject Centre[2] and the Team has given a presentation to this group. The Team also presented their work at the 10th International Conference on Technology on Mathematics Teaching[3] and at the CETL-MSOR Conference 2011[4]. This project has also been extended to and is assisting students enrolled at Liverpool's partner university in China[5].

A system 'toolkit' has been developed — providing sample code, instructions for use and advice based on the Team's experience — and is available from the website. Changes and improvements are ongoing.[6]

There are potential time-saving benefits through this approach, but this method needs careful planning so that it is not detrimental to the quality of teaching or the student experience. In particular, structured MATLAB teaching to ensure all students have basic programming skills is needed before students use the automated assessment system.

The Project Team has also considered whether this automatic assessment system could work in the context of another high-level mathematics programming language (for example Maple). This might be done in one of at least two ways:

- Translate everything directly into Maple equivalents
- Reconstruct most of the student and tutor interfaces into a web form which then calls a mathematics engine, such as Maple, to run the submitted and reference codes. The assessment (comparison and reporting) script can then be written in any language

However, there may be technical problems when only using Maple, which does not have the equivalent of the packaged version of a MATLAB file. This file type is required for the reference code and the student self-testing code. However, several well-documented examples of invoking MATLAB and Maple applications from the web exist and so a version of this project as web forms may work well.

[2]For details on the HEA, see: http://www.engsc.ac.uk/

[3]For details of the conference, see: http://ictmt10.org/

[4]For details of the conference, see: http://mathstore.ac.uk/?q=node/1572

[5]For details of Xi'an Jiaotong-Liverpool University, China, see: http://www.liv.ac.uk/xjtlu/. The Project Team provided the teaching materials used and provided access to the assessment material to staff at XJLU. There are large numbers of students in XJTLU but most of them come to Liverpool when taking modules related with the automated assessment. Therefore the number of students using the material at present within China is unknown

[6]Although many of the materials are available from the website, not all the resources have been made publicly available. However, a full, compiled version of the toolkit is available on request. Anyone interested in receiving a copy should contact the Project Lead in the first instance for further details

Stimulating student-led employer-focused activity in engineering, chemistry, physics and mathematics at Loughborough

Project Lead: Fiona Lamb, Sarah Bamforth and Glynis Perkin,
Centre for Engineering and Design Education, Loughborough University

Collaborating institutions: Imperial College London (Alison Ahearn); JCB Power Systems; Rolls-Royce plc; Royal Academy of Engineering; Higher Education Academy Engineering Centre; Institute of Mathematics and its Applications; Institute of Physics; Royal Society of Chemistry

Abstract

Loughborough University has an established institutional ethos of working with employers to develop industry-ready graduates, yet continues to strive to enhance this further. Supporting and encouraging students to combine their academic study with relevant activities beyond the assessed components of their degree programmes is seen as potentially beneficial and this project provided an opportunity to explore the feasibility.

The project encouraged the formation of groups of students who were interested in undertaking student-led, employer-focused activities. Funding was provided to successful students to enable them to jump-start their ideas. A strong partnership was formed at both staff and student level with Imperial College London where there is well-established student-led activity. The success of this initial project has led to further funding and development, including a checklist resource[1] to support other universities interested in student-led activity.

Background and Rationale

Loughborough University has a well-established institutional ethos to work with employers to develop industry-ready graduates; much of this interaction is delivered within the curriculum.

However, Loughborough recognises that students could be further encouraged and supported to combine their academic study with relevant activities beyond the assessed components of degrees. For example, students at Imperial College London complete overseas construction projects and organise their own site visits through dynamic student societies. Employers highly value such activity, which is seen to retain students within STEM, provide students with additional vital relevant work experience and demonstrate the dedication and motivation of these students.

The project aimed to enhance the quality of STEM education at Loughborough through the stimulation of relevant extra-curricular student-led activity to develop employability skills. The rationale being to encourage STEM students, in groups, to bid for funding to initiate and undertake activities and to ensure the activities were sustainable in the long term. The active involvement of senior management, employers and professional bodies as well as consultations with students undertaking similar activities elsewhere aimed to inspire the Loughborough students.

The project aligned with two of the strategic aims of the National HE STEM Programme, namely the higher education curriculum strategy to enhance the learning experience for students and the Programme strategy to develop STEM graduate skills.

Implementation

An initial meeting was held with senior management and members of Loughborough University Students' Union to agree the approach to be taken to secure strong

[1]Checklist available from http://cede.lboro.ac.uk/studentledactivity/ [accessed 5/7/12]

institutional support. Members of staff, students and representatives from industry and professional bodies were then invited to a subsequent meeting where the initiative was explained. A further student meeting was held when the call for proposals was officially opened. At this meeting students were invited to form groups and bid for funding to set up student-led extra-curricular activities that were employer-focused. The level of funding available for each activity was set at approximately £1000.

"The best thing about the student-led activities is that our ideas could be brought to reality and make a real difference to people's lives."
Student Participant of Student Led-Projects Initiative, Loughborough University

Following this student meeting, two groups of students with well-structured ideas sought and were given permission to submit early proposals. This requirement for a formal proposal was important to encourage students to take the process seriously. The two proposals were:

- Loughborough branch of Engineers without Borders[2] – this is a charity that helps engineering students to tackle poverty overseas. (Funded and successful)
- Students' Union STEM umbrella society – this would support groups of students with setting up their student-led activities. (Accepted for funding but the idea was subsequently withdrawn)

A panel, comprising staff, a member of the Student Union executive, Imperial College London and representatives from industry and professional bodies, then met to view the proposals that had been submitted in response to a full call. Three proposals were selected for funding:

- Industrial Trips for Chemical Engineering – students provide opportunities for chemical engineering students to visit industrial plants across the United Kingdom
- Mars Aerobot Project – students worked with the National Space Centre[3] to produce an interactive display prototype
- EcoHomes: An energy saving challenge – students set up a recycling material and energy saving competition between student houses

A further project was later funded:

- Conference and Events Committee – students organise events to showcase their work to employers

Each project was allocated one or more advisors (academic, industrial, professional body) whom the students could contact for help if required. Regular meetings were arranged with the students to ensure the activities were progressing satisfactorily. All participating students provided progress reports and feedback on the project.

A Skype 'Discovery' Conference held with staff and students from Imperial College London enabled the Loughborough University students to benefit from the expertise of those at Imperial.

Evaluation

Success of the project has been measured by the enthusiasm of all involved, in particular from the employers and professional bodies. Short-term success was indicated by the quality and dedication of the students involved and the range and ambition of the projects proposed.

Longer-term success has been measured by the sustainability of the projects over time. Some of the original projects are still ongoing, new projects are still being established. The idea of student-led symposiums to showcase and further enhance activity developed from this initial project and has been very successful. The level of interest from other universities has been extremely high and has led to a Practice Transfer Adopter Scheme and the development of a checklist resource. These were all unanticipated outcomes of the project.

Another unanticipated outcome of the project is the working relationships that have developed both internally at Loughborough and externally with Imperial College London. For example, the Centre for Engineering and Design Education has worked with the Employability Award Co-ordinator at Loughborough to develop an online searchable database of extra-curricular activities. The database includes, but is not restricted to, STEM activities. This is an excellent additional outcome for the project that helps to ensure that the knowledge gained through the student-led activities is sustainable in the long-term.

Short-term sustainability has been achieved. A number of the groups established have undertaken activity that reached well beyond the length of the original project. It is hoped that the connections made with employers, professional bodies, the Student Union and other staff at Loughborough, will enable long-term support for such initiatives.

Discussion

Enablers included the following:

[2]For details, see: http://www.ewb-uk.org/ [accessed 5/7/12]

[3]For details of the National Space Centre, see: http://www.spacecentre.co.uk [accessed 5/7/12]

- Enthusiastic high quality engaged students.
- Engaging relevant parties at an early stage and working closely with them. Their high quality input, advice and enthusiastic support to both the project team and students was crucial. Involving them in formal meetings from the start and getting their active participation in selecting projects worked well and gave them ownership with the groups.
- Allowing students to suggest their own activities or go with a suggested idea – both of which were funded.
- Help and support from staff and students at Imperial College London. The fledgling activities at Loughborough benefited from the expertise of those involved with the well-established activities at Imperial. Use of Skype technology reduced travel costs and made better use of time.

There were of course also barriers. These included:

- Attracting sufficient numbers of students to engage with the project was initially a problem. The most successful method found to encourage students to take part was for each relevant Departmental Administrator to email all the students in their department. This resulted in over 180 initial expressions of interest with students from seven departments eventually being involved.
- A time-consuming problem with formalising the establishment of the more subject specific and smaller groups as student societies. This led to insurance and funding issues until resolved through the creation of an over-arching society.

Sustainability

This project has grown and evolved beyond expectations, developing into further projects. Additional external sponsorship has funded ongoing activities and a number of publications have been produced to document outcomes[4].

There is ongoing significant interest in the project and the idea is felt to be transferable to all STEM disciplines and beyond[5]. However, it should be noted that at Loughborough it seemed easier to engage engineers and chemists than mathematicians and physicists.

Two mentors were appointed to each project so the students have someone to turn to if they encounter unexpected difficulties or unfamiliar bureaucracy. The mentors can also ensure that the students' ambitions are realistic in view of the time they will have available.

Finally, the project team have found it to be a very rewarding and worthwhile experience to work with such motivated and enthusiastic students.

[4]Including a journal paper in Issue 7.1 of Engineering Education and conference papers for HEA STEM Conference 2012, HE STEM Annual Conference 2012 and EE2012.

[5]For more information regarding student-led activity including the checklist and relevant publications, see: http://cede.lboro.ac.uk/studentledactivity/ [accessed 5/7/12]

Student laboratory skills at the transition into HE chemistry

Project Lead: Nigel Lowe, Department of Chemistry, University of York

Collaborating institutions: University of Southampton; University of Bristol; University of Bradford

Abstract

This project aimed to build on the philosophy, methods and experiences of a number of UK chemistry departments to embed activities that will support the development of student laboratory skills before and after embarking on an undergraduate chemistry course.

The aim of this project was to develop resources to support first year practical chemistry through the creation of videos and pre-laboratory exercises delivered through the institutional virtual learning environment (VLE). The project will build upon best practice of an existing pilot project and significantly extend it to provide coverage of all areas of introductory practical chemistry.

The project aimed to bring together representatives from established projects at the University of Bristol and the University of Southampton. As a result, the project was not only able to build upon an inventory of support materials specific to the University of York, it also drew directly upon the experience of established practitioners.

Background and Rationale

It has been recognised for a number of years that delivering a meaningful experience of laboratory work to large undergraduate classes can result in a 'recipe book' approach that deprives students of the opportunity to engage with skills such as experimental design and hazard assessment.[1] In response, the 'pre-lab' exercise offers the chance to explore the underlying experimental design and laboratory procedures and can also address shortfalls in prior experience that face new university chemistry students, not least due to the under-representation of laboratory work in the secondary sector.

The HEFCE-funded Royal Society of Chemistry 'Chemistry for our Future' initiative focused on the wide disparity of student laboratory experience at the 'transition' into higher education[2] and facilitated the production of video resources to support potential and actual undergraduates.[3] Additional HEFCE support for the laboratory sciences Centre for Excellence in Teaching & Learning at the University of Bristol ("Bristol ChemLabS"), further illustrates the potential of a holistic approach to supporting laboratory work through a combination of video, quizzes, animations and virtual experiments.[4]

Against this background, the Project Team obtained some institutional funding in summer 2009 to support a pilot project to embed a suite of comparable resources in their VLE. These resources were tailored to their own experiments, equipment and laboratory environment, and were evaluated in the academic year 2009-10. It was clear that students were reassured by access to photos and videos of equipment, techniques and procedures. Pre-laboratory quizzes were less popular, viewed as a chore rather than an opportunity to understand the experiment and underlying chemistry.

This project presents the opportunity to extend the VLE-based approach to cover all the first year practical work. By involving experienced practitioners and by working in tandem with another department with similar aspirations (the University of Surrey[5]), the Project Team is able to incorporate best practice and minimise duplication of effort.

Implementation

The project began with a half-day meeting to establish links between collaborators and share best practice and aspirations. The meeting, which attracted 37 internal and external delegates, focused on how best to implement

[1]S. W. Bennett, K. O'Neale, U. Chem. Ed., 1998, 2, 58

[2]The Chemistry for our Future programme was a £3.25 million pilot project, funded by the Higher Education Funding Council for England between September 2006 and August 2008. The Royal Society of Chemistry managed the project. For more details, see: http://www.rsc.org/Education/CFOF/

[3]The Interactive Lab Primer - A visual guide to common laboratory techniques. For details, see: http://chem-ilp.net/

[4]For details about Bristol ChemLabS, see: http://www.chemlabs.bris.ac.uk/

[5]For details of a similar project also funded by the National HE STEM Programme, see Case Study 19 of this report

resources to support laboratory work, building on the experiences of Bristol and Southampton and creating a 'support network' between York and Surrey.

The funding allowed us to appoint six undergraduate students to five-week projects over the summer of 2010. Their brief was to produce video resources to complete coverage of the first year chemistry course. The Team had access to a digital video camera and a software package to edit and export finished clips.

The students established a methodical approach to reviewing the course-practical scripts, authoring pre-lab questions and identifying some 44 techniques and procedures to commit to video. The student team also identified some key topics covered in years two and three of the chemistry course as well as generating resources suitable for schools.

With the transition to higher education in mind, the Project Team also aimed to develop resources for schools, at Year 12–13 level, to provide virtual access to facilities and procedures beyond the scope of most schools. Video resources were prepared and the authoring of the complete resource is ongoing. The materials were trialled and refined as part of a third year undergraduate 'Chemical Communication' project, where students collaborate with a local school to disseminate the resources. One of the instructional videos is featured on the 'Chemistry Review' website.[6]

[6]Chemistry Review is a widely read post-16 chemistry publication aimed at schools. For details, see: http://www.philipallan.co.uk/chemistryreview/index.htm

Evaluation

The project has delivered 44 instructional videos — ranging from 30 seconds to 4 minutes — which, along with 22 pre-existing videos, now encompass the entire first year course. The Team have also created materials aimed at schools to introduce the concepts and practice of university-level practical work prior to transition. The half-day meeting in York brought together collaborators and other institutions to facilitate sharing of best practice at the outset of the project.

Almost all of the materials developed under this project were not used immediately, meaning formal evaluation was delayed. Early informal feedback was very positive, not least from academic colleagues who have previously relied on rather cumbersome video-disk technology to provide technique reminders to students returning into their second year.

Evaluation took place indirectly through a general questionnaire taken by students at the end of their first year. The most telling response that reflects the introduction of full video support is the question "How did the VLE support your learning?" since 75% responded with 'Invaluably' (top category) or 'Strongly' (next to top category) compared with figures of 37%, 57% and 42% in the previous three years respectively. Whilst there is a degree of variance within the data, a correlation between the introduction of the enhanced video coverage and the jump in percentage is noted.

These VLE-based resources will be evaluated through an end-of-term module questionnaire. Previously, the 2009 pilot project was subjected to evaluation through a bespoke questionnaire where feedback was strongly in favour of video and generally appreciative of the whole 'VLE packaging' of experiments. The Team is therefore optimistic that these new materials will be well used.

The Team's 2009 pilot project established a 'house style' for captioned, instructional videos delivered in high-definition and standard formats. Content was refined through an iterative process involving laboratory technical staff, junior (postgraduate student) and senior (academic staff) laboratory demonstrators and large-group screenings.

Other pre-lab materials, principally pre-lab questions, were proof-read by the academic in charge of each experiment to ensure accuracy and consistency of style and content across laboratory courses.

"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."

Nigel Lowe, Department of Chemistry, University of York

Discussion

Institutionally, the e-Learning Development Team at York provides great assistance in matters relating to the VLE. This included funding for a pilot VLE project under which videos to support first year practical work was established in 2009.

Departmentally, the support for Teaching Fellows allowed supervision of summer undergraduate project work and facilitated liaison with academic staff. Recent investment in improved IT facilities in Teaching Labs has added an extra impetus to making further improvements to this project. Bench-top computers provide the option for accessing the VLE during laboratory sessions.

There were some communication problems dealing with the large number of academic staff with responsibility for different parts of the practical course. There were also issues with laboratories being in use during some periods of the project, by Open University summer schools and Salters 'Chemistry Camps'.

The main issues during implementation have been technical ones; such as idealised data rates for streaming video and student access to the VLE. It has also been difficult for teaching staff to make students aware of the requirement of pre-laboratory work, although this situation improved as the term progressed.

Sustainability

Students welcome, and increasingly expect, multimedia approaches to support their learning, be it podcast lectures or instructional videos for practical work. Feedback collected during the pilot phase confirms that students find these latter resources helpful at a time when they are increasingly concerned about their lack of preparation for practical work at university.

The individual nature of departmental laboratory courses, instrumentation and facilities will always necessitate some degree of 'in-house' production of supporting resources. However, there is a tradition of sharing teaching philosophy and materials in the physical sciences through bodies such as the National HE STEM Centre[7] and the Higher Education Academy Physical Sciences Centre[8]. The Project Team strongly recommends a survey of existing materials and approaches before embarking on development projects. It is easy to envisage similar projects at other higher education institutions to support classes in all practical STEM subjects.

The Project Team has positive experiences of the contribution that undergraduates can make to developing educational materials particularly those relating to laboratory work where they have a uniquely prescient perspective. This contribution can be supported through extracurricular projects like this one and through undergraduate project work, such as the 'Chemical Communication' projects offered to BSc students at the University of York who are considering a career in teaching.

This project has successfully developed pre-lab materials to complete the support offered for first year chemistry practical sessions.[9] The department's approach to delivering practical work is now inextricably linked to using the VLE to provide supporting material and when new experiments are proposed the process of video-recording key techniques and procedures is written into plans at the outset. There has also been a number of informal conversations with colleagues in the departments of physics, biology and electronics who are keen to implement similar projects.

Materials have also been prepared for use in schools to address the transition between school and university. Extension of the project to cover topics for second and third years has begun, and the VLE site now has content for all years establishing it as a coherent, developing resource in support of laboratory work.

[7]For details, see: http://www.nationalstemcentre.org.uk/

[8]For details, see: http://www.heacademy.ac.uk/physsci/

[9]The Project Team would like to acknowledge the work of a number of people who, in particular, have contributed to this project: Dr Nick Wood supervised the undergraduate summer project; Dr Annie Hodgson advised on trialling and refinement of the materials for schools. Dr David Read, University of Southampton and Dr Paul Wyatt, University of Bristol offered valued advice; the dedicated team of undergraduate project students were Robert Baker, Peter Bramwell, Liam Curless, Alexandra Glenister, Amy Ruddlesden and Nicholas Taylor

Embedding resources for distance learning

Project Lead: Tina Overton, Department of Chemistry, University of Hull

Collaborating institutions: The Royal Society of Chemistry; Higher Education Academy Physical Sciences Subject Centre

Abstract

The aim of this project was to develop an existing Foundation Degree in Chemical Science from part-time day-release mode to distance-learning mode. The project aimed to embed existing resources from previously funded work, and increase access to higher-level-skills development to those in full-time employment or further education colleges. The course was to build upon expertise gained from a successful pilot. The Foundation Degree course was successfully designed and relaunched for distance-learning students and is proving to be very successful in terms of increased recruitment and student progress. The existing resources were not embedded within the new programme but did inform the design of resources used. While this project is tailored for students of Chemical Science, expertise on the development of distance-learning courses is directly transferable to those wishing to enhance or develop similar courses in all STEM subjects.

Background and Rationale

The University of Hull has run a Foundation Degree in Chemical Science since the early 1990s. The Foundation Degree runs as a part-time day-release course and, following a successful online pilot, the Project Lead wanted to develop a full distance-learning programme.

A Foundation Degree is a university-level qualification designed for a particular area of work or expertise. It is generally regarded as being equivalent to the first two years of an honours degree course and has a workplace-based element or a vocational nature. While Foundation Degrees have grown in popularity in recent years[1], both they and online distance-learning courses are rare in the STEM disciplines. Therefore this new course, together with a parallel development in engineering, would be the first at the university in a STEM subject.

The National HE STEM Programme has a number of high-level strategic aims and this project addressed many of them directly. A new distance-learning Foundation Degree would require development of curriculum content and rely on the latest teaching methods and up-to-date technology for course delivery and design. Non-traditional students would be expected to enrol for this online course, and the needs of students from further education colleges, the current workforce and those who live in remote locations can all be met. This course would widen participation and strongly develop higher-level skills.

It was initially intended that resources developed as part of a previously funded project would be incorporated into the new Foundation Degree. The existing resources were developed as part of the Chemistry for our future[2] (CFOF) programme funded by the Higher Education Funding Council for England to enhance distance-learning provision. CFOF invested in the development of resources to support part-time education in chemistry. It comprised four 20-credit modules covering organic, inorganic, physical and analytical chemistry. One of the modules was developed at the University of Hull and was successfully piloted with part-time students. Although the design and development expertise for these resources was valuable, it quickly became clear that the CFOF outputs themselves could not be incorporated directly into the new online course and so new materials were prepared.

A level-4 skills gap in chemicals-related industries has been identified[3]. Although the University of Hull has an established Foundation Degree in Chemical Science delivered as a part-time day-release course, employers in the region have reported that day-release is becoming untenable in the current financial climate. This is a bigger issue than that of fees for employers. Initial

[1]For news on foundation degrees, see: http://www.telegraph.co.uk/education/educationnews/8257855/Students-turning-to-two-year-foundation-degrees.html

[2]The Chemistry for our future programme was a £3.25 million pilot project, funded by the Higher Education Funding Council for England between September 2006 and August 2008. The Royal Society of Chemistry managed the project. For more details, see: http://www.rsc.org/Education/CFOF/

[3]Data supplied from Cogent, see: http://skillsreport.cogent-ssc.com/industries-chemicals.htm for details

market research[4] has demonstrated that participation in higher education would increase for those working in the industry if the mode of delivery was more flexible and included more work-based learning.

This project's aim was to develop a distance-learning version of the FdSc in Chemical Sciences currently running at the University of Hull. Funding was requested to support five undergraduates to work with an academic team over the summer of 2010 to develop an online presence in the virtual-learning environment, develop support materials and convert existing learning resources to a format appropriate for distance learners.

Implementation

The project worked to modify and develop the existing FdSc in Chemical Science course running at the University of Hull into a distance-learning version. This course also includes 40 credits of work-based learning and applied chemistry modules, which were developed in consultation with employers and are focused on industrial chemistry.

Four undergraduate students were employed for four weeks in July 2010 as a summer placement outside their usual studies. During this time the students worked alongside a team of five members of academic staff to convert existing materials into a format suitable for online distance learning and to set up a virtual identity for the new programme on the university's virtual learning environment.

A member of academic staff evaluated the teaching materials produced through the CFOF project. These materials were felt to be too diverse in style and structure with each using a different textbook. The decision was made to choose a single textbook for students on this course and that existing learning resources developed by the academic staff at the University of Hull provided a better basis for course development. A single textbook would simplify and enhance the learning experience for the student. A developmental programme to develop the transferable skills of the students was also embedded in the course and is supported through an e-portfolio.

Work over the summer period of 2010 focused on preparing the learning resources for year 1 of the new distance-learning course. Resources required for year 2 of the programme were developed during the summer of 2011 by the academic staff team. Working on this new course also provides an excellent continued professional development opportunity for the members of staff involved.

[4]The market research was carried out by the project team who contacted employers who have sent students on the Foundation Degree course in the past. The project team also spoke with current students to get a full understanding of their needs

The project has led to a full-scale launch of the distance-taught course. The course has recruited 13 students for the academic year 2010–11 compared to three students enrolled for the day-release version in 2009–10. All the students are employed in the chemical industry, and one student is from Brussels. The distance learning has been supplemented with on-campus induction and occasional workshops. All students have succesfully completed assignments. They sat their first formal examination in January 2011 and are now in their second year of studies.

Evaluation

A Foundation Degree in Chemical Science was successfully designed and launched for distance learning and is proving to be very successful in terms of increased recruitment and student progress. To date, teaching and learning materials equating to 120 credits have been developed. The funding provided by the National HE STEM Programme was used towards developing the online course presence and some of the course materials.

The only barrier encountered during this project was the decision not to use the CFOF-produced resources. However, a problem did not result because the decision was made quickly and it was felt that more appropriate resources already existed within the chemistry department which could replace the originally intended ones. The Project Team encountered no other significant barriers. There was a strong commitment to make the development a success from the academic staff team who were supported by the Head of Department.

Key enablers were the support of the Head of Department — who prioritised this activity for the staff involved — and funding from the National HE STEM Programme to pay the five undergraduate students who took the lead on preparative work over the summer months.

Previous to this new distance-learning course being developed, recruitment onto the day-release version was dropping with only seven students enrolling for academic year 2008-2009 and just three students the following year. Feedback from employers indicated that this drop in enrolment numbers was likely due to the difficulty employers had in releasing employees from the workplace. The relaunch of the course in September 2010 attracted 13 students. Enquiries for 2011 recruitment were received shortly after, and these students, now part of the second cycle of the redesigned course, have begun their studies. On this basis alone the development has been a great success. In addition, the students enrolled as part of the first cycle of the course are making good progress so far, with 12 out of 13 students passing the first assignments. Further evaluation of the new course and its success will take place once the course is completed.

The newly designed course was subject to the University of Hull's internal validation and quality assurance procedures. The course went through a full validation process during which it was subject to scrutiny by the Academic Approvals Committee. Departmental processes such as module questionnaires and module review will also be used in the same way to evaluate this course as for all modules delivered in the department. In addition, a postgraduate student is studying the impact of this change of delivery mode as part of their research project.

Discussion

This new course has had an impact at many levels. It has added to the course portfolio of the department 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 the chemistry department to engage with a wider range of employers. There is continued commitment within the department to continue development of such modules. Therefore, online provision will grow beyond that which has been funded by the National HE STEM Programme and will enable the chemistry department to add online distance-learning modes of delivery to its expertise.

This project has demonstrated the viability of both Foundation Degrees and distance learning across the STEM HE sector and provides a model for cost-effective development.

The Project Team were careful to make sure a number of strategic plans and checks were put in place to ensure the success of this work both in terms of the standard of student experience and cost-effectiveness. The following points are suggested for others wishing to undertake similar developments:

- Carry out market research to identify the need for provision and ensure that developments meet these needs
- Use undergraduate students for help. They are close peers to the students you wish to attract and often have good technical skills
- Identify a core team of committed academic members of staff to develop the course and support students; this ensures consistency and coherence in course delivery
- Face-to-face induction helps build the student community; fully engaged students are likely to perform better
- On-campus laboratory practical sessions may be essential for a STEM course
- Make materials as interactive as possible to include self-tests, worked examples and model answers
- Use online fora for tutorials, support and networking

Sustainability

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. The expertise staff have gained is encouraging them to look at developing access routes for students and continued professional development provision.

Course development is set to continue. The National HE STEM Programme funding acted as a pump primer, enabling the change in mode of course delivery. Funds from the host department allowed for additional support to kick-start the activity. Staff within the department are committed to the activity and will continue to develop it.

Looking to the future, the Project Team also intends to apply their expertise to extend their portfolio of online-learning courses and develop an access route to their Foundation Degree to run alongside their Masters-level provision of courses offered as continued professional development.

Stimulating techniques in entry-level mathematics (STEM) with a computer-aided system for teaching and assessment using a computer algebra kernel

Project Lead: Chris Sangwin, Mathematics, Statistics and Operational Research Network, University of Birmingham

Collaborating institutions: University of Manchester; Loughborough University; University of Leicester

Abstract

All STEM subjects share a core of knowledge and skills in entry-level mathematics. This includes the topics of numeracy, algebra and linear algebra, trigonometry, geometry and single-variable calculus, which are all covered in GCE A-level mathematics or equivalent qualifications. With the decrease of emphasis on mathematics within the science curriculum and the modularisation of A-level qualifications, there is ever more need to identify weakness in mathematical skills and support students to address them.

This project was designed as an assessment intervention to link existing computer-aided assessment technology with existing practice materials targeted to support the needs of an individual student.

This project aimed to take existing diagnostic tests in mathematics and develop automatic tests for the STACK computer-aided assessment (CAA) system.[1] The outcome would be a user profile that links to existing online learning materials. The primary aims of this project therefore were to produce:

- A taxonomy of core skills, the majority of which are linked to questions that test these skills
- Question files arranged into 3 tests. These tests are for:
    - Students with A or B grade in A-level mathematics
    - Students with C grade or below in A-level mathematics or only AS-level mathematics
    - Students without A-level mathematics
- Software extensions to STACK that embed links to targeted online learning materials
- A demonstration server
- A workshop at the Higher Education Academy's Maths Stats and OR Network (MSOR Network) conference

Background and Rationale

Diagnostic testing in mathematics is widespread and has been used for many years. It is recommended that students embarking on mathematics-based degree courses should have a diagnostic test on entry and that prompt and effective support should be available to students whose mathematical background is found somewhat lacking by these tests.[2] Extensive series of case studies in diagnostic testing have already been published.[3] Furthermore, there have been specific CAA systems for diagnostic testing such as DIAGNOSYS.[4]

[1]For details, see: http://www.stack.bham.ac.uk/

[2]T. Hawkes, M. Savage, Measuring the mathematics problem. Technical report, The Engineering Council, 2000

[3]D. Lawson, Diagnostic Testing for Mathematics. LTSN MathsTEAM Project, 2003. For a download of the report, see: www.engsc.ac.uk/downloads/mathsteam/diagnostic_test.pdf

[4]J. Appleby, P. C. Samuels, T. T. Jones, DIAGNOSYS – a knowledge-based diagnostic test of basic mathematical skills. Computers in Education, 1997, 28, 113–131

STACK is an online computer-aided assessment system for mathematics. STACK uses the computer algebra system Maxima to:

- Randomly generate problems in a structured mathematical way
- Establish the mathematical properties of expressions entered by the student, i.e. multiple-choice questions are not used routinely
- Generate outcomes such as a numerical score, feedback that may include mathematical computations of the student's answer, and a note for later statistical analysis

STACK was developed at the University of Birmingham, with support from the MSOR Network. STACK is available under the GNU General Public License.[5,6,7,8,9] The STACK community site hosts a wiki that includes documentation.[10]

Implementation

Following an initial meeting, and informed by research,[11,12] the following design decisions were made:

- Numerical scores on individual questions and tests would not be available to students, instead, text-based feedback (for example, "correct answer") will be used
- Diagnosis will be at broad topic level (for example, "algebra" or "calculus" and not at the minute detail of individual technical skills)
- Multiple-choice questions would only be used when this is the most appropriate format. In general, students should be expected to answer with a number or algebraic expression
- Students will always have an opportunity to say "I don't know" and move on
- A strong preference should be given to questions which instruct the students to find the answer
- Confidence-based testing would be used. Each question should contain a "slider" to enable the student to indicate their confidence with each answer
- Each test should start with the student being asked for basic information, such as the type and level of their mathematics qualifications
- Tests should be developed that are fair to students who have done what the school examination system has asked of them
- The diagnostic tests would contain questions that assess each of the curriculum topics listed in the QCDA GCE Advanced Subsidiary (AS) and Advanced (A) Level Specifications Subject Criteria for Mathematics.[13] But, questions on Numerical Methods, should be omitted
- The tests should take no longer than one hour with the students being allowed to use a pencil and paper but not a calculator

A comparison was made between existing diagnostic tests from UMIST and Loughborough University, and the QCDA specification. Despite trying to maintain simplicity, 103 "core skills" were identified and grouped into two levels. The first level contains 17 categories, which are then further subdivided. For example, subskills for the Equations core skill include: Solve Linear Equations; Solve Simultaneous Equations (EQN-SIM); Solve Quadratic Equations (EQN-QUD); and Solve Inequations (EQN-INQ). When answers are assessed, each is assigned a tag or tags to indicate whether a student has or has not demonstrated a particular skill or skills. To build the student's profile the tags are counted. When several skills are assessed by one question, these tags accumulate. The reporting software then examines these tags to build the profile and match up appropriate follow-up materials.

The QCA's Subject Criteria for Mathematics discuss more general skills such as proving and problem solving. In particular they claim, "these requirements should pervade the core content material set out". While there are technical limitations when trying to assess proof with STACK, some questions have been developed to do so. These can be found under the core skills of Logic, Analysis of Diagrams and Analysis of Word Problems. While these questions can be time consuming for students they are of importance in mathematics education.[14]

[5] For more details on GNU, see: http://www.gnu.org/

[6] Y. Nakamura, The STACK e-Learning and Assessment System for mathematics, science and engineering education through Moodle, chapter Preface, pages vi–vii. Tokyo Denki University Press, 2010. In Japanese. ISBN 978-4-501-54820-9

[7] C. J. Sangwin, Assessing Elementary Algebra with STACK. International Journal of Mathematical Education in Science and Technology, 2008, 38, 987–1002. To download the article, see: web.mat.bham.ac.uk/C.J.Sangwin/Publications/2006CASAlgebra.pdf

[8] C. J. Sangwin, Who uses STACK? A report on the use of the STACK CAA system. Technical report, The Maths Stats and OR Network, School of Mathematics, The University of Birmingham, 2010. To download the article, see: web.mat.bham.ac.uk/C.J.Sangwin/Publications/2010-3-1-STACK.pdf

[9] I. Wild, Moodle 1.9 Math. Packt Publishing, 2009. For details, see: http://www.packtpub.com/moodle-1-9-math/book

[10] For details, see: http://stack.bham.ac.uk/wiki/

[11] A. N. Kluger, A. DeNisi, Effects of feedback intervention on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. Psychological Bulletin, 1996, 119, 254–284

[12] V. J. Shute, The future of assessment: Shaping teaching and learning, chapter Tensions, trends, tools, and technologies: Time for an educational sea change, pages 139–187. Taylor and Francis Group, 2007

[13] In May 2010 the Government announced its intention to close the Qualifications and Curriculum Development Agency (QCDA) as part of its wider education reforms. National curriculum assessment are now performed by the Standards and Testing Agency, which is part of the Department for Education

[14] C. J. Sangwin, Modelling the journey from elementary word problems to mathematical research. Notices of the American Mathematical Society, 2011. To download the article, see: web.mat.bham.ac.uk/C.J.Sangwin/Publications/Sangwin2011AMS.pdf

Evaluation

This project has been successful in stimulating and supporting the practice of techniques in entry-level mathematics by building on existing best practice in diagnostic testing, and support materials. The objective to take existing diagnostic resources and transfer these by developing and deploying tests for the STACK computer-aided assessment system was met. Over 80 questions are available as part of the STACK software distribution, and modifications to the STACK code have also been released to enable reporting of outcomes of the tests.

The outcomes of the project relied on collaboration between institutions. The University of Birmingham's School of Mathematics and School of Physics and Astronomy, the University of Manchester School of Mathematics and Loughborough University Mathematics Education Centre worked together to develop the materials. Collaborations with Aston University and Coventry University helped identify resource materials.

Testing the materials with students was not possible within the specified funding time period. The University of Birmingham and the University of Manchester have since used the diagnostic tests in the autumn of 2010 with approximately 350 students. Following on from these tests the Project Team has evaluated the work done here. It has been decided that the structures put in place for building student profiles is sufficiently valuable to warrant the effort expended in developing a skill classification scheme and tagging all questions individually.[15]

By taking tried and tested paper-based diagnostic tests from respected colleagues the Project Team have confidence that the underlying questions are useful and sound. The authoring of questions was an iterative process. Ultimately the checklist for quality control included the following:

- A uniform naming strategy – denoting the core skill addressed
- Keywords – including the level of the core skill
- A description of the question
- Random versions with an appropriate question note
- A full worked solution
- Formative feedback
- Outcomes from the potential responses are tagged
- Question tests include (i) correct and (ii) likely incorrect answers
- Confidence based "slider" test

Feedback and a full worked solution for each question was included to enable them to be used in a formative setting.

[15] Plans to expand the framework started in this project are temporarily on hold while the Project Team collaborates with the Open University to release a new version of the underlying STACK software

Discussion

The success for this project has hinged on a number of factors. Key enablers were:

- The availability of STACK as an open-source CAA system for mathematics
- The availability of existing paper-based tests and the generosity of colleagues in giving permission to use them
- The MSOR Network for hosting their annual conference, which was key in the dissemination of the project
- The post of 'STACK developer' at the University of Birmingham to modify STACK's reporting mechanism rapidly within the timescale of the project

The project also faced a few challenges. The Project Team found that writing questions together in a uniform manner takes considerable planning and effort. To overcome this problem the Team used a wiki to record the evolving design decisions, and to document the checks needed at each stage of question authoring. Pressure on time meant that the questions could not be tried on the students within the original timescale of the project, although this was done as soon as practical.

The project also required some software extensions to STACK to be written in parallel with the questions. This was not ideal and resulted in some wasted time, because details of the tagging scheme for the reporting mechanism evolved with the project.

Sustainability

This project has raised the profile of CAA within the University of Birmingham, and contributed to a modest expansion in its use.

Dissemination of the outcomes of this project has taken a number of forms. The project homepage acts as a repository for all reports regarding outcomes of the project. All the questions used as part of this project have been added to the STACK website and been made available for download.[16] The software code developed for the reporting section of this project has also been added to the STACK system. This means that anyone wishing to develop or set up a similar testing system can readily do so. In addition, a talk was given at the annual conference of the MSOR Network.[17]

The Project Team have modified the content of the tests in the light of experience during the 2010-11 teaching cycle. This activity will continue as part of core teaching at the institutions involved.

[16] The questions developed have been released under Creative Commons Attribution-Share Alike

[17] For details, see: http://mathstore.ac.uk/?q=node/1572

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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