The UK Higher Education Academy Physical Sciences Centre

Wavelength is the newsletter of the UK Physical Sciences Centre (part of the Higher Education Academy).

...enhancing the student experience in chemistry, physics, astronomy and forensic science within the university sector

ISSN 1745-8447 (Print)
ISSN 1745-8455 (Online)

Volume 7, Issue 1

Summer 2011

Wavelength

This issue...

In this issue we have a larger than usual number of articles including:

- A summary of some of the highlights from the Graduate Skills Surveys, undertaken by the Centre with chemistry, physics and forensic science students across the UK.
- A report on a project at the University of Liverpool, supported by the Centre, into the practicalities of recording lectures and how the recordings are used by students.
- A summary of the progress made so far by the Working Higher project, in which the Centre is a partner, to develop a suite of foundation degrees.
- Reports from twelve Development Projects, funded by the Centre, covering subjects from digitisation of a skeleton to produce a teaching aid, a diagnostic tool for assessing data-handling skills, the use of concept maps to improve literature review skills, and a board game to teach green chemistry.
- Reports from four Departmental Projects, a new type of project funded by the Centre, covering a study of students' problem solving skills, the use of personal response systems, producing screencasts and the use of pre-lab virtual experiments.
- The winning entry from this year's Student Award competition, where entrants were asked to submit their answer to the question 'Imagine you are a lecturer for a day. How would you teach your students?'. Food for thought and maybe some inspiration.
- A farewell tribute to a long-serving member of the Centre, Roger Gladwin, who retired earlier this year.
- The latest information on the future of the Higher Education Academy, the Subject Centres and our annual conferences.
- Details of the Development Projects funded by the Centre for this year.

This will be the last issue of Wavelength. We hope you have enjoyed receiving this publication and found the contents useful. ■

Inside this issue...

The newsletter is free of charge to academics in UK higher education institutions. The material is also published electronically on our web site.

Graduate Skills Surveys

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The UK Physical Sciences Centre has carried out surveys of the skills required by chemistry, physics and forensic science graduates during the first few years after graduation and the development of these skills within their degree programmes. The surveys also collected information on the graduates' activities since graduation. Full details on how these surveys were carried out and the results have been given in three reports available online (HEA UK Physical Sciences Centre 2010a, 2010b and 2010c) or in printed format on application to the UK Physical Sciences Centre. The full data sets from these surveys, including all the open-form question answers, but without graduate and university names, are available online (HEA UK Physical Sciences Centre 2011a, 2011b and 2011c).

This article takes an overview of the results obtained in these surveys and indicates some ways in which they can provide guidance for more effective practice in HE.

Guidance for degree developers
The survey results provide much information to guide those involved in developing physical science degrees, whether at the national level for degree bench-marking and accreditation or at the university department level for individual degree programmes. In all three subjects there were mismatches between the usefulness of areas of knowledge/skills after graduation and the extent to which they were developed within degree programmes. This particularly applies to some generic (also known as transferable) skills.

Recommendations in the survey reports include:

- When undergraduate chemistry degree programmes are being revised, additional opportunities should be provided for developing generic skills, in particular oral presentation. Additional opportunities should also be provided for planning and design of experiments, skills with chemical instrumentation and analytical techniques.
- When undergraduate physics degree programmes are being revised, additional opportunities should be provided for developing generic skills, in particular oral presentation and computing. Additional opportunities should also be provided for planning and executing experiments/ investigations and interpretation of results.
- When undergraduate forensic science degree programmes are being revised, additional opportunities should be provided for developing generic skills, in particular computing, statistics, report writing and oral presentation. Additional opportunities should also be provided for development of analytical skills, including more hands-on laboratory experience. Crime scene related areas of knowledge need to be maintained in degree courses and if possible expanded.

The survey results are already starting to have an impact, with an academic at one of the collaborating departments reporting that: *"The findings from this survey are now feeding into our curriculum - we are making changes to try to address some of the 'deficient' skills."*

Guidance for students
The surveys provide much information to assist physical science students in getting the most out of their degree studies by indicating the skills required by new graduates. Particularly relevant are the results obtained in response to the survey question asking graduates to indicate which areas of knowledge/skills they wish they had been given more opportunity to develop within their degree. The results are shown in Figures 1, 2 and 3.

The survey results provide much information to guide those involved in developing physical science degrees...

Graduate Skills Surveys

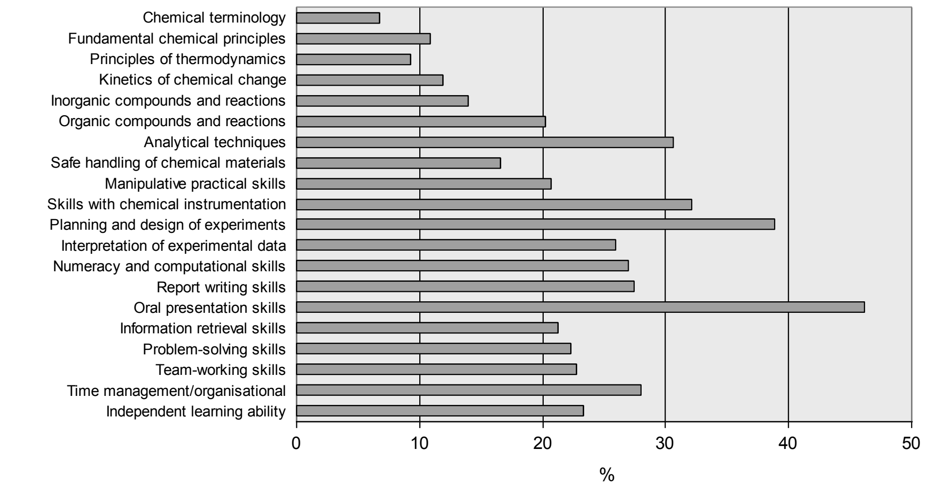

Figure 1: Percentage of chemistry graduates indicating they would have liked more opportunity to develop the areas of knowledge/skills in their degree (average score is 23%)

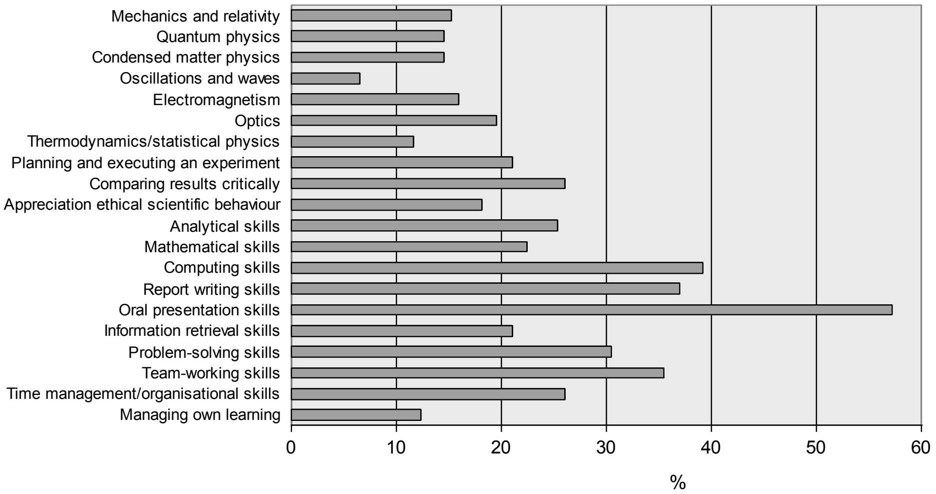

Figure 2: Percentage of physics graduates indicating they would have liked more opportunity to develop the areas of knowledge/skills in their degree (average score is 23%)

The surveys provide much information to assist physical science students in getting the most out of their degree studies ...

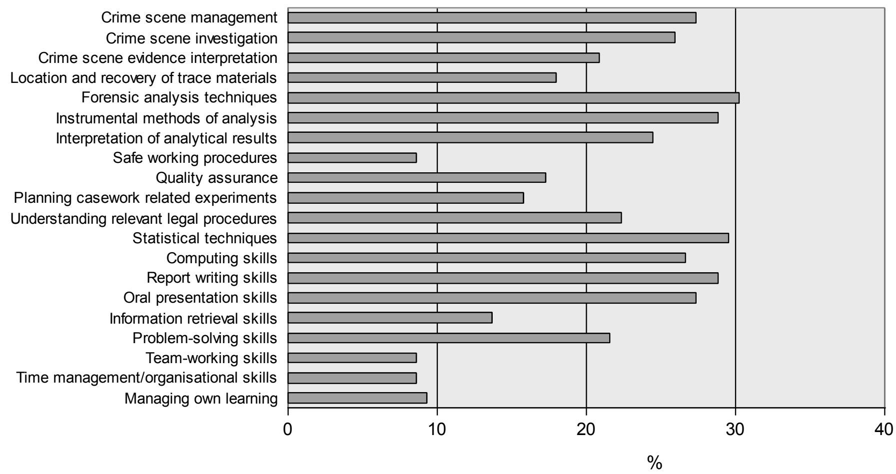

Figure 3: Percentage of forensic science graduates indicating they would have liked more opportunity to develop the areas of knowledge/skills in their degree (average score is 21%)

Graduate Skills Surveys

For chemistry graduates, oral presentation was scored highest, followed by planning and design of experiments, skills with chemical instrumentation and analytical techniques.

For physics graduates, oral presentation was scored highest, followed by computing skills, report writing skills, team-working skills and problem-solving skills.

> *...it is recommended that forensic science students should be advised of the importance of obtaining relevant work experience.*

For the forensic science graduates several areas of knowledge/skills were scored highly, namely: crime scene related; analytical skills; statistics and computing; and report writing and oral presentation.

It is recommended in the survey reports that students should be advised about the skills new graduates require (in particular the generic skills) and that presentations by recent alumni may be one of the best ways to put over this message, which is not always readily accepted by students. In addition it is recommended that forensic science students should be advised of the importance of obtaining relevant work experience.

Guidance for potential students
The survey results can inform potential students (and new students) when making decisions about the courses to undertake and modules to study.

It was found that 56% of physics graduates and 71% of forensic science graduates had had little or no subject involvement in their activities since graduation. This could have a bearing on whether a potential student decides to opt for a joint degree or subject with degree rather than a single subject degree. For example for physics graduates: in many of the careers being followed which had little or no physics content, then degree study with a higher computing or mathematics content would have been an advantage. Many forensic science graduates had moved into jobs in related sciences in which more laboratory based content in the degree study would have been of value. One forensic science graduate commented that: "*Since graduating I have found it very difficult to get a job in forensics due to lack of lab experience! This, together with few jobs, has helped me make the decision not to go into forensics, however, this needs to be explained to people before they do this degree otherwise it's a waste of time. I'm now pursuing a career in biomedical science."*

Many of both the chemistry and forensic science graduates indicated the value of gaining work experience during degree study. This is relatively easy for potential chemistry students as there are many degrees available with placements. Forensic science students may have to organise their own work experience although there are now a few degrees with placements.

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Graduate Skills Surveys

If a research career is foreseen by potential students, then it should be noted that 20% of chemistry and 22% of physics graduates in these surveys were undertaking PhD study, compared with only 3% of graduates from the more applied forensic science degrees. However the government is currently reviewing research & development in forensic science, which could lead to changes in the amount of research work being undertaken in academia (Home Office, 2011).

It may be thought by potential students that an integrated Masters degree is required for those wishing to undertake PhD study, but in this survey more than 25% of chemistry and physics PhD students had taken the shorter BSc degrees before moving directly into PhD study (a further 10% in each case had taken an MSc degree between the BSc and PhD degrees). As student fees increase, the shorter BSc route to PhD entry could prove more appealing.

Many of both the chemistry and forensic science graduates indicated the value of gaining work experience during degree study.

References

1. HEA UK Physical Sciences Centre (2010a). *Skills required by new chemistry graduates and their development in degree programmes.* <www.heacademy.ac.uk/assets/ps/documents/graduate_skills/chemistry.pdf>
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Providing Recordings of Chemistry Teaching

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Previously, the Higher Education Academy offered funding for projects as part of its first round of a discipline-based organisational development programme to enhance learning through technology. The Chemistry department at the University of Liverpool was successful in being one of the eight projects funded in round one. As part of the work the UK Physical Sciences Centre provided support during the project, acting as a team member.

The Academy badged this initiative is a catalyst for the transformation of practice across a department and Liverpool's project was based around the creation of audio and video recordings of teaching sessions given by lecturers. These recordings were then made available to students as teaching resources and revision aids. One of the goals of the project was to encourage at least ten members of academic staff to engage in the project and also develop good practice for a simple approach to recording sessions without needing expensive equipment or creating more work for the lecturer. The project formally concluded January 2011, achieving all of its aims.

Background
For the two years previous to the start of the project the team leader recorded lectures and made them available to students via the university's virtual learning environment. These recordings may be viewed on a desktop computer (Figure 1a) or downloaded to a personal media player (Figure 1b). The video recordings capture all "on screen" activity, e.g. PowerPoint presentations, websites, animations etc. along with the associated audio, whilst the audio recordings capture the vocal part of the lecture. The idea was that the students should not use this as an alternative to lecture attendance, as they would lose the opportunity for questioning and feedback, but rather as a supplement to aid learning.

Alignment with Internal and External Policies
The project is aligned with HEFCE's Enhancing Learning and Teaching through the use of Technology policy, as the project enhances flexibility and choice for learners, enhances student achievement, improves access, meets learners' expectations, potentially attracts and retains students and supports the diversity of speed of learning within the student body. Additionally, the project is aligned with University of Liverpool e-learning policy which has been informed by the Bologna Declaration (to support student learning), Government policy (provision of out of hours opportunities to learn, more and better flexible ways to study) and JISC (creation of a better learning environment for all learners). The university's policy recognises e-learning as an aspect of the blended learning approach to enhance student learning. This project is aligned with the local policy of embedding e-learning within all parts of the university.

Benefits
There are many perceived benefits of the proposed project for the student learning experience:

- Enables more effective revision
  Revisiting the recordings when revising, supplements the students lectures notes, textbooks and other sources
- Increases student engagement particularly outside traditional "contact hours"
  Use of the recording by students maximises the potential for learning and they can access the material anytime day or night via a computer with internet connection
- Promotes personalisation of learning for the students
  Students can choose where, when and how they view/listen to the recordings maximising the potential for learning
  Supports flexibility of learning in a diverse student body

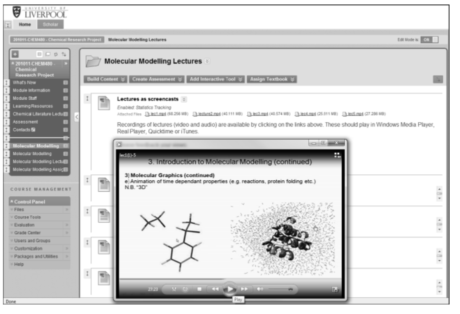

Figure 1a): Screenshot of recorded lecture on PC

Figure 1b): Screenshot of recorded lecture on mobile device

Providing Recordings of Chemistry Teaching

Provides resources for students with different learning styles who perhaps do not fully engage with “traditional” learning and teaching methods to successfully engage. Students with audio/visual disabilities have the ability to revisit material enhancing the chances of successful learning. Similarly students for whom English is not there first language can use the resources to hopefully achieve effective learning. The recordings also offer a solution for students who miss lectures due to illness or other eventualities

- Encourages active learning on the part of the student
  Students who use the material provided via the recordings are much more likely to become active learners once engaged
- Supports student progression
  Evidence exists that use of such recordings has a positive influence on the student progression rate
- Promote lifelong learning
  Through using the recordings students may realise they are more receptive to material presented in this way, informing their preferred individual learning style for future life
- Learner entitlement
  Enhance equality between students (disabilities, language)

The benefits to staff include:

- Higher levels of student engagement which should lead on to higher and/or more rapid achievement
- Increased rates of student progression leading to higher retention rates overall.

Practical Aspects

The practical aspects of the recordings have been shown to be quick, easy and cheap. The software needed to perform the screen and audio capture conversion to a format suitable for a personal media player or computer (Debut video capture <www.nchsoftware.com/capture/ index.html> is free. The setup time is less than 2 minutes and uploading to the virtual learning environment is equally quick.

Successes so far

Through the efforts of the project team at Liverpool there are now over 10 academic colleagues who are recording their teaching sessions. In addition there are currently another 4 colleagues who are just about to start recordings. In total the recordings cover over 25 different modules and well over 100 lectures have been captured across all undergraduate year groups.

Evaluation

The project evaluation consisted of two parts: i) staff reactions and ii) student reactions.

i) Staff reactions: Conversations and discussions of team members with colleagues concerning their experiences of recording lectures have informed us of the “staff reaction” which has been universally positive. Evidence has been gathered that shows that the provision of the recordings has no effect on lecture attendance. This finding mirrors a growing body evidence from other departments and institutions.

ii) Student reactions: The student reaction has been assessed via access statistics on the virtual learning environment, a student focus group and via the staff student liaison committee. The reaction has been extremely positive with evidence showing that across all modules and all year groups the recordings have been used by a large proportion of the students. The students liked the availability of the recordings and found them particularly useful either for revision (Figure 1 c) i)), revisiting a portion of the lecture they found challenging either because the lecturer “went too fast” or the student “missed it” or to further annotate notes taken in the lecture.

The idea was that the students should not use this as an alternative to lecture attendance, as they would lose the opportunity for questioning and feedback...

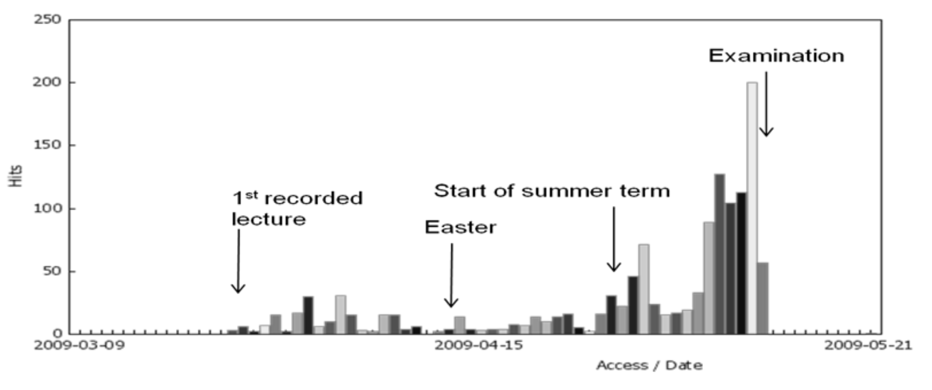

Figure 1c) i): Access statistics for one module by date

Providing Recordings of Chemistry Teaching

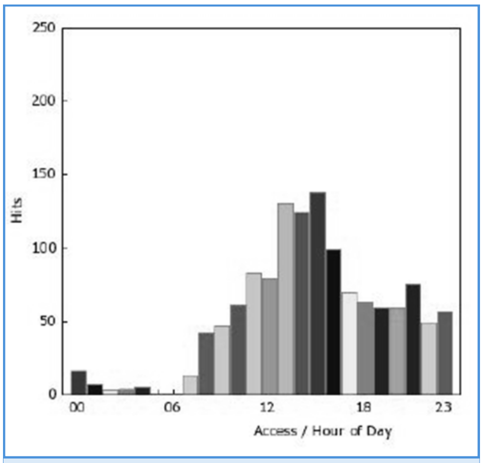

Figure 1c) ii): Access statistics for one module by hour of day

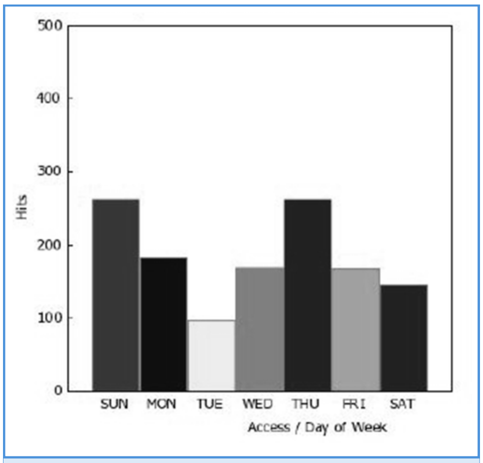

Figure 1c) iii): Access statistics for one module by day of week

They found the ability to "fast forward" and "rewind" to certain points of the lecture particularly useful (Figure 1 a) and b)) as was the ability, on occasion, to turn the volume up to make the lecturer more audible. Across a wide range of modules students accessed the recordings on every day of the week and at all times of the day (Figure 1 c) ii) and iii)). It is noteworthy that students engaged on distance learning courses were particularly supportive of the lecture recordings. Generally, students accessed the recordings using a desktop PC. It is notable that students did not want the recordings to replace the lecture experience as they felt they would miss out on the interactive experience and feedback that the face-to-face lecture offers. There was also evidence for increasing demand from students for more lectures in different modules to be recorded.

Quotations from students given below support the general conclusions:

> *"The lecture recordings are brilliant, thanks!"*
> *"The recorded lecture really helped me."*
> *"The recordings are really useful."*
> *"I just watch the sections I am having difficulty with - probably making notes."*
> *"I watched all of the recording for a missed lecture, and made notes. For revision – I skipped to relevant parts."*
> *"I used the recordings for revision."*
> *"I watched several bits on sections I did not understand and made notes."*
> *"Generally I go to relevant part or recording - sometimes listening to those bits more than once."*
> *"The recordings are very useful as I can go back over the material - would be very useful in most modules".*

Sustainability

As an indication of the sustainability of the project, all members of staff who recorded lectures last academic year are now recording this year's lectures "as a matter of course". This is taken as an indication of how easy it is to record the lectures (once the initial "training" has occurred) and that there is "no reason not to record lectures". There is increasing evidence from conversations with colleagues that colleagues are beginning to discuss lecture recording amongst themselves – not instigated by members of the team. If this continues then the likelihood of colleagues recording their lectures will continue to increase. There is anecdotal evidence that the delivery and content of lectures

There is increasing evidence... that colleagues are beginning to discuss lecture recording amongst themselves – not instigated by members of the team.

Providing Recordings of Chemistry Teaching

improves motivated by the fact that the lecturer knows that they are recorded. On a practical level discussion with computer services has indicated that there should be no problem on the storage capacity of the virtual learning environment to store the recordings.

The practical aspects of the recordings have been shown to be quick, easy and cheap.

Dissemination

Internal communications with members of staff have been via staff meeting, teaching & learning committee and informal discussions with colleagues all raising awareness of project and sharing experiences. Further internal communication has been by team members “training” colleagues on how to record their lectures and mount them on the virtual learning environment.

Additionally, the project has several associated web pages:

- Higher Education Academy (gives an overview of the project)
- <www.heacademy.ac.uk/projects/detail/DFLTEA1_Liverpool>
- UK Physical Sciences Centre (contains an example short recording of one of the recorded lectures
- <www.heacademy.ac.uk/physsci/home/projects/recordingedlectures>
- University of Liverpool iTeach (contains a case study of project on the University’s Centre for Lifelong Learning Inclusive Teaching – iTeach - site)
- <www.liv.ac.uk/eddev/iteach/case_studies/iTeach_Case_Study_E-Learning_in_Chemistry.doc>

Where next

This project has successfully demonstrated that teaching sessions can be quickly and easily captured to act as teaching resources and revision aids for students, without the need for expensive equipment or specialist technical help. Staff use continues to grow, with ever increasing numbers of sessions being recorded. With the impending opening of a new teaching facility preparation is being made to facilitate recording of sessions in the new building. Additional work will now focus on looking at ways of recording other aspects of lecture delivery techniques (such as the blackboard/whiteboard and OHP) to provide a richer record of a teaching session for students.

References

1. <www.nchsoftware.com/capture/index.html>
2. In the original setup MediaCoder (free opensource) was used. I found a better all inclusive (capture and format conversion integrated) – Debut screen capture. Not open source, but free. (Certain aspects are time limited demo but these aren’t necessary for what we want)

Staff use continues to grow, with ever increasing numbers of sessions being recorded.

...anecdotal evidence that the delivery and content of lectures improves motivated by the fact that the lecturer knows that they are recorded.

Working Higher

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Working Higher is a £2.9m employer engagement collaborative project between the UK Physical Sciences Centre, Cogent Sector Skills Council and the University of Hull. The project is funded by the Higher Education Funding Council for England (HEFCE).

The aim of the project is to develop a suite of flexible, work-based Foundation Degrees to a national specification in collaboration with a consortium of HEIs. The HEI partners involved in the project are:

- Gareth Neighbour and David Sowden, University of Hull, Process and Chemical Engineering
- Jonathan Francis and Stephen Kirkup, University of Central Lancashire, Nuclear Engineering
- Michael Cole, Manchester Metropolitan University, Chemical Science
- Mathew Philip, London Metropolitan University, Polymer Technology
- Helen Thomas and Ian Cumming, University of Kent, Applied Bioscience Technology

The aim of the project is to develop a suite of flexible, work-based Foundation Degrees to a national specification

The Foundation Degrees have been designed in collaboration with leading employers so that business improvement, knowledge and skills are quickly applied and embedded within the workplace. The programmes hope to offer organisations a tailored programme, which meshes with their needs. The programmes are offered via a blended learning pathway, with emphasis on work based learning.

Each HEI partner has had the expertise and input of an Industry Champion, selected based on their strong connections with industry and knowledge of training and development in the sector. Industry Champions have been vital to facilitating employer engagement to ensure that the Foundation Degrees remain close to the needs of industry and their employees. The following have been employed in this role:

Process and Chemical Engineering

Gareth James, recently retired from a career with BP of 31 years and has significant prior experience in working with skills bodies.

Nuclear:

Allison Hunt, Nuclear, has been seconded from Magnox North, where she is employed as their Learning and Development Planning Officer.
Martin Wells combines his role as Project Manager for the National Skills Academy (postgraduate) Certificate of Nuclear Professionalism initiative with the OU to raise demand for qualifications in the sector.

Chemicals

Robert Green has 38 years experience in the chemical industry in various technical and training.

Polymers

Jeremy Pingstone is Managing Director of ITS Plastics Ltd offering technical support, project management, training and NVQ programmes to the sector.

Bioscience

Brian Szukala has held senior Learning and Organisational Development positions at both Pfizer and Abbott and most recently as Business Services Director at SeerPharma UK Ltd.

The Industry Champions have played an important role to facilitate employer

The Foundation Degrees have been designed in collaboration with leading employers so that business improvement, knowledge and skills are quickly applied...

Working higher

engagement. They have worked with the consortium to define generic work-based modules within the FDs and also are working to customise work-based modules for each sector.

By utilising these Industry Champions with

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strong employer links, the Foundation Degrees have been developed with emphasis on satisfying employer needs. The Industry Champions have also brought skills and knowledge, currently not present within the HEIs, allowing a greater range of skills development to be incorporated in the programmes such as leadership and management and business improvement. The industry Champions have advised about content and development to employer needs are met.

The project is now into its final stages with the Foundation Degree in polymer technology launched in January 2011, and the remaining four Foundation Degrees will be launched later in the year. A website has been launched to provide details on all the Foundation Degrees to employers and potential students, <www.workinghigher.org>.

Alongside the project, research has been carried out on the use of work based learning (WBL) and the models currently in use evaluated. How WBL is incorporated into the programmes and its impact on student learning will be evaluated. A practice guide, 'An Introduction to Work-based Learning' has recently been published which gives an overview of some of the current literature exploring work-based learning, as well as outlining case studies of work-based learning modules currently implemented at several Higher Education Institutions (HEIs) throughout the United Kingdom. This guide should provide the reader with a general idea of how work-based learning is approached and how module outlines can be created and adapted to appeal to HEIs, employers and learners. The practice guide is available to download, <www.heacademy.ac.uk/assets/ps/documents/practice_guides/practice_guides/work_based_learning.pdf>.

For further details contact the Working Higher Project Team at workinghigher@hull.ac.uk
Website: <www.workinghigher.org>
■

...By utilising these Industry Champions with strong employer links, the Foundation Degrees have been developed with emphasis on satisfying employer needs.

The project is now into its final stages with the Foundation Degree in polymer technology launched in January 2011...

Development of Animated Visualisations

Development Project Report

Enhancement of Student Conceptual Understanding of Quantum Mechanics through the Development of Animated Visualisations based on Outcomes of Educational Research

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The aim of this project was to develop and evaluate a new resource for teaching quantum mechanics concepts, consisting of animations and animated visualizations (collectively called animations in what follows), each focusing on a particular difficulty. The project built on the substantial number of studies into student difficulties and misconceptions in quantum mechanics, as well as our own lecturing experience. All animations are freely available at : <www.st-andrews.ac.uk/~qmanim> and can be run directly from the site as well as individually downloaded. The website includes instructor resources consisting of worksheets with full solutions. These resources are password-protected, instructors are asked to email ak81@st-andrews.ac.uk to obtain the password.

Overview of the animations

In this project, we developed 25 animations in total for introductory and intermediate-level quantum mechanics. The animations were created in Adobe Flash. Calculations were performed using Mathematica and graphs then imported into Adobe Flash as a series of static vector curves. The animations have a small file size (typically 80 kB for 1D, and 2 MB for 3D animations) and only need Flash Player to run. All animations have a similar “look-and-feel” and are intuitive to use.

Key features of the animations that make them effective for learning include interactivity, emphasis on time-dependent behaviour, comparison with classical systems, animated step-by-step explanations of key points, and the adaptability to a variety of learning goals. The animations cover a range of topics including bound states in 1D potentials, 1D scattering, time-dependent phenomena, measurement, 2D potentials, perturbation theory, spin and angular momentum and multiparticle wave functions.

Each animation includes an “animation” tab and a “step-by-step exploration” tab. As an example, consider the animation on probability current (also called flux of probability current or probability flux, see figure 1). Students are often adept at calculating the probability current for a given wave function, but may still be unable to explain its significance and lack a mental image of its meaning. One of the reasons for this difficulty is the rather complex relation between the probability density and the probability current, which is difficult to demonstrate without an animation.

The animation shows the time-dependent probability density and the probability current for an equally weighted superposition of ground state and first-excited state in a 1D infinitely-deep square potential well, and allows the user to overlay various quantities, such as the slope of probability current at a fixed position. Choosing the “step-by-step exploration” tab (shown in figure 1) will stop the animation, and then explain the relation between the slope of probability current at a given point and the temporal rate of change of probability density at that point. Figure 1 shows a screenshot of the step-by-step exploration after two steps have been displayed.

Evaluation

We used the animations in two St Andrews quantum mechanics courses, namely the level two Quantum Physics course (taken by students in their first or second year of study) and the level three Quantum Mechanics 1 course (taken by students in their second or third year of study). In the Quantum Physics course, students used two of the animations, the Potential Step and the Finite Well, in a one-hour workshop with set problems. In Quantum Mechanics 1, five of the animations were used in tutorial problems, and a number of animations were used in the lecture to promote discussion and visualize outcomes of calculations.

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Development of Animated Visualisations

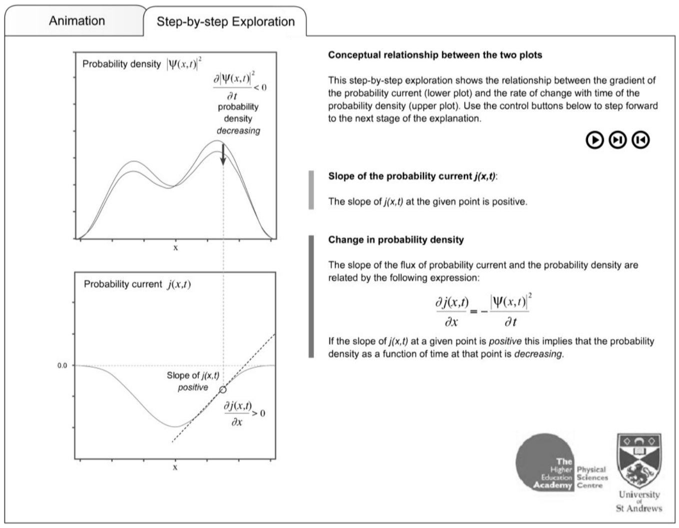

Figure 1: A screenshot of the animation "Probability density and probability current". The figure shows the "Step-by-step Exploration" view with two of the steps being displayed

...students were also asked to rate the animations they had used in the workshop in terms of their usefulness in improving understanding...

Evaluation consisted of a questionnaire on student use of and attitude towards the animations given to level three students, as well as a diagnostic survey administered to level two students in a pre- and posttest format as well as to level three students. Level two students were also asked to rate the animations they had used in the workshop in terms of their usefulness in improving understanding, and to comment freely on the animations.

On the whole, students were very positive about the animations, e.g. on a scale of 1 (not useful) to 5 (very useful) the average rating for the Finite Well animation was 4.1 (standard deviation 1.0), and 3.9 (standard deviation 0.9) for the Potential Step animation. One student comment was "*They were incredibly useful. It's good to get "hands on" with what sometimes feels like a "hands off" topic*." The level three results were similarly positive. More critical comments pertained to the quantity and level of the explanations, and led us to critically review and amend the animation texts.

The diagnostic survey results showed that level 2 students outperformed level 3 students on four of the twelve questions in total. Of these four, the two highest outperforming questions were on the topics of the animations used in the workshop, namely the finite well (50% more correct responses at level two than at level three), and the potential step (38% more correct responses at level two than at level three). Level 3 students had not used these two animations. Thus, these results may indicate that using the animations had a positive effect on student understanding. However, the results only demonstrate short-term learning gains, as the posttest was administered shortly after the workshops, and the long-term effect on learning remains to be investigated. ■

One student comment was "They were incredibly useful. It's good to get "hands on" with what sometimes feels like a "hands off" topic."

HASDiP2

Development Project Report

The Hulton Abbey Skeletal Digitisation Project - HASDiP2 – Use of non-contact laser digitisation to capture images from fragile skeletal material for use in teaching and research.

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Background

The aim of the previous HASDiP project was to produce a digitised record/ resources from skeletal material recovered from a well publicised excavation of historical importance in Stoke-on-Trent, Staffordshire. This excavation took place at Hulton Abbey and produced a published book as part of its work. This skeleton's history is well known and documented[1].

Whilst the initial aim of this project was to produce digitised resources which will be actively used for forensic science teaching at Staffordshire University and Reading University these can equally and readily be adopted by other organisations and institutions. In addition, due to the interdisciplinary interest in this work, the potential for re-purposing and re-use of these digitised resources is enormous. Due to the anatomical nature of the skeletal excavations there is potential for use in anthropological and biological (e.g. disease) studies and there is also historical and religious sociological and cultural applications as well as in photographic studies, computing and e-learning technologies.

...due to the interdisciplinary interest in this work, the potential for re-purposing and re-use of these digitised resources is enormous

This next step (HASDiP2) allows for the use of a non-contact laser digitisation device which offers data to compliment the existing photographic information. It also helps to strengthen further a new relationship to take the whole digitisation of skeletons to the next logical step which is a *national* strategy of digital archiving of fragile and relatively inaccessible skeletal material.

Digitisation process

The VIVID 910 employs laser-beam light sectioning technology to scan workpieces using a slit beam. Light reflected from the workpiece is acquired by a CCD camera, and 3D data is then created by triangulation to determine distance information.

The laser beam is scanned using a high-precision galvanometric mirror, and 640 × 480 individual points can be measured per scan. In addition to distance data, furthermore, this 3D digitizer can also be used to acquire colour image data. Employing a rotating filter to separate the acquired light, the VIVID 910 can create colour image data.

The project was initially designed to be completed using the Konica VI-910. A three day event was planned at the Natural History Museum in London with colleagues who kindly allowed access to their kit. The equipment was functional but awkward to use and the data was difficult to manipulate. One of the precepts of this project was to be confident that minimal algorithmic manipulation of the laser captured data occurred. This would offer confidence that the images viewed were accurate and precise computer representations of the bones scanned.

As a consequence of the issues with data capture using the Konica, another piece of equipment was sourced and investigated. The FARO-arm scanner was found and the bones scanned at their headquarters.

The data was easily captured with minimal manipulation to produce 3D renders of the bones being scanned.

...the next logical step... a national strategy of digital archiving of fragile and relatively inaccessible skeletal material.

HASDiP2

Digital images
The 3D image files can be easily viewed using a freely downloadable piece of software from MiniMagics. This software allow360 degree rotation, zooming, image capture and measurement of distances etc.

The data observed and generated from these 3D images can be compared and contrasted in a complimentary fashion using the HASDiP project (images available from the UK Physical Sciences Centre[2].)

Potential of the project outcomes
The skeletal material can be used by a variety of educationalists to disseminate findings about the people that were buried at Hulton Abbey. The digitised virtual catalogue will allow the skeletal material to be examined by a wider audience, whilst preventing the unavoidable damage that occurs when handling such friable material and should ensure the skeletons live-on for many years after their physical manifestation ends.

For this project to be a successful, not only is the permanent preservation of the friable skeleton paramount, but so too, is the use of the digital resource by a variety of users for their own particular learning outcomes. Ideally, those who utilise this digitised resource for their own purposes will have set learning outcomes which generically could include:

1. Understand and undertake the methods of producing accurate archaeological/ anatomical drawings/photography
2. Understand and apply the requirements of archaeological/anatomical recording procedures.

In addition, the following transferable skills could be developed and enhanced:

1. Critical thinking
2. Team working and independent working
3. Communication skills, written and oral
4. Observational skills
5. Problem solving skills
6. Recognition, description and reporting skills
7. Accuracy in working and reporting
8. Analytical and practical skills
9. Numerical skills.
10. Enhanced visual literacy in the making, understanding and interpretation of forensic photography.

This material would facilitate and promote better understanding of skeletal material for osteology, anthropology, archaeology anatomy, pathology and forensic science teaching etc in the UK.

...should ensure the skeletons live-on for many years after their physical manifestation ends

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(This)...will allow the skeletal material to be examined by a wider audience, whilst preventing the unavoidable damage that occurs when handling such friable material...

This material would facilitate and promote better understanding... for osteology, anthropology, archaeology anatomy, pathology and forensic science teaching etc in the UK.

Teaching and Assessment Resources

Development Project Report

Teaching and Assessment Resources for Medical Imaging for Physics Students

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Project summary
The aim of the project was the development of four simulation tools for the learning and teaching of medical imaging. The simulators were developed in IDL and distributed as executables based on the IDL Virtual Machine, which doesn't need a full IDL license to run. Together with the simulators, worksheets and assessment questions to be included in the UK Physical Sciences Centre Question Bank[1] were developed.

Simulation software

A) Planar imaging simulator
The tool simulates X-ray images of an object with an embedded detail, starting from geometrical parameters (dimensions of source, object and detail) and physical parameters (beam energy, scatter/primary ratio on the image plane, attenuation coefficients of object and detail statistics) of the system. It allows the user to carry out measurements of average and standard deviation on regions of interest, to plot profiles of the image along selected lines, and to save the images for analysis with other programs.

B) X-ray Computed Tomography (CT) simulator
The previous version of the software was upgraded in order to include a wider range of parameters (e.g. object size and detail size) and more advanced features, such as the use of a choice of polychromatic beams. Albeit computationally time consuming, this feature was deemed essential to support the understanding of beam hardening artefacts and their importance for different object sizes and spectra.

The user can perform ROI measurements, like in the planar imaging simulator, and measure profiles along lines, the latter feature being useful to highlight beam hardening artefacts. Image data can be saved in 32-bit tiff (preserving the original characteristics of the data) and as jpeg (for display) formats. Profile data can be saved in ASCII format.

C) Receiver Operating Characteristic (ROC) curve simulator
The ROC curve gives an estimate of the accuracy of an imaging system and observer. Familiarising with the concept is particularly important not only for physics students, but also for students of medical disciplines (radiologists, radiographers).

This simulation tool includes most of the routines developed for the Planar Imaging simulator. The user chooses a number of images to be generated, as well as which parameters (statistics, detail diameter and thickness) should be kept constant. The software will then generate a number of images with a 70% probability of a detail being present. The detail has a random position in the field of view and the non-fixed parameters are randomly generated within pre-determined ranges. For each image, the user selects, on a scale of 1 to 5, their degree of confidence of a detail being present (from 1 = 'definitely not' to 5 = 'definitely yes'). According to this, the software computes the ROC curve (true positive rate vs. false positive rate).

Data of the generated images can be saved and reloaded for second evaluation (by another user, or by the same user under different conditions, e.g. different lighting conditions). When a previously saved data set is reloaded, the order of images is randomly altered in order to avoid any bias in case of the same user performing the detection task.

ROC curve data can be saved in ASCII format.

D) Modulation Transfer Function (MTF) simulator
The MTF is a measurement of the capability of an imaging system of reproducing the different frequency. It is routinely used in quality assurance in imaging departments.

This simulation tool is more suitable for postgraduate students (e.g. Medical Physics MSc) generates the Modulation Transfer Function of an indirect X-ray detector (i.e. a detector which is coupled to a scintillating material, which converts X-rays into visible light which is detected by the device), starting from a user-defined pixel size and a choice of two scintillators. An image of an ideal tilted edge is generated, blurred according to the characteristics of the scintillator chosen and sampled with the pixel size. The MTF is calculated from this image according to well-established procedures. MTF data can be saved in ASCII format.

Teaching and Assessment Resources

Students agreed, in general, on the usefulness of the simulation tool and were willing to use it for revision in preparation for the exam...

Worksheets and questions

The worksheets produced relate directly to the simulation tools, providing guidance in manipulating the tools and directions for investigations to be carried out using the tools.

In some cases the worksheets are differentiated for students of differing abilities to enable both access by less able students and extension of more able. An example are the ROC worksheets, where one sheets describes a possible method to calculate the area under the curve, whereas the other leaves this to the student to work out and has addition independent investigations to be carried out. This allows all students to understand the basic concepts and provides opportunities for some to pursue the topic further.

The assessment questions, whilst relating to the tools and grouped in topics around each simulator, are not specific to them and can be used in the assessment of the principles of medical imaging whether or not the student has had access to the simulators. However examples are taken from the simulators, thus familiarity with the tools will aid the student when attempting the assessment questions.

Many of the assessment questions have been designed to provide feedback, both by providing guidance within a question if requested by the student (with a corresponding drop in marks awarded if the question forms part of a formal assessment) and when the answers and scores are reported.

The interactive questions have been written to comply with IMS standards and can be used in the UK Physical Sciences Centre Question Bank.

Evaluation

Due to the timing of the project, evaluation so far was only possible for the planar X-ray imaging simulator on a small cohort of seven students attending the Medical Imaging module at Surrey. Students agreed, in general, on the usefulness of the simulation tool and were willing to use it for revision in preparation for the exam, although two problems were highlighted:

1. Most students scored as “neutral” their agreement on whether the simulator provided a complete description of image formation. This suggests that two points should be addressed in future use: firstly, it should probably be stated more clearly that a simulator by its very nature provides only a partial model of the process. Secondly, other features could be added to the next versions of the simulator.
2. Students reported difficulty in accessing the IDL virtual machine for working on their home computers. Translation of the software to Java, to guarantee easier access to students, will be considered for the future.

Further evaluation, through questionnaires for students and lecturers, will be done in the next year.

Future of the project

All components of the simulation software are being upgraded in order to be made cross-platform and crash-safe. Once completed, a project web page will be set up, where the software, with detailed instructions, and the worksheets will be available.

References

Question Bank <www.heacademy.ac.uk/physsci/home/projects/questionbank>

■

Many of the assessment questions have been designed to provide feedback... by providing guidance within a question if requested by the student ...

Data-handling Skills

Development Project Report

Data-handling Skills in the Physical Sciences: development of a diagnostic instrument and supporting learning resources

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Pilot distribution of test and evaluation
The pilot distribution of the data handling diagnostic test we have developed was completed in May 2010. We visited almost all partner institutions and have been able to collect more than 1200 student responses, across 10 institutions (7 Physics and 4 Chemistry departments). We have gathered data across all undergraduate years (including integrated Masters years). The most comprehensive dataset is, naturally, Edinburgh Physics students, where we have obtained 508 responses from 78% of the total student cohort. We have also been able to survey multiple years at other institutions, including Physics departments in Glasgow, St Andrews and Liverpool.

This comprehensive pilot dataset has enabled us to perform a through evaluation of the validity and reliability of the instrument. Standard statistical tests have been used and have shown the instrument to perform very well. We have made minor stylistic and typographical changes to four of the questions in the light of the pilot exercise. This evaluation has also brought to light some interesting findings.

Performance on the test is *surprisingly consistent*, across all years, both Physics and Chemistry and across institutions. Intra-year variation is substantially larger than inter-year or inter-institution variation. This is strongly suggestive of a set of skills that are acquired comparably poorly by all students, irrespective of institution, or year of study. Figure 1 indicates the mean test score (out of 23) for Edinburgh Physics students, as a function of cohort year (error bars represent standard error on the cohort mean).

The only statistically significant change is seen between years 1 and 2. During this period, students undertake a short course specifically designed to improve data handling skills. Whilst the data clearly show that this instruction is effective in improving overall ability as measured by the test, it is equally obvious that these skills are not further developed during the remainder of the undergraduate degree programme.

An example of a fairly straightforward question is one about standard deviations and standard errors. The students are required to use the data given in the question to calculate the standard deviation (using the equation given as a tip), then must divide this value by the square root of the number of measurements to obtain the standard error on the mean. A minority of students do this and obtain the correct answer, 'B'. Of the remainder, the overwhelming majority give answer 'C', which corresponds to the standard deviation (rather than the standard error). We believe this occurs because most students do not have a firm grasp of the difference between the standard deviation and the standard error. These topics are frequently taught in a rather recipe-based way – having calculated a standard deviation, the next step is seemingly to arbitrarily divide it by √N for reasons that are not clear to the students. Consequently, this step is easily forgotten by the students taking the test.

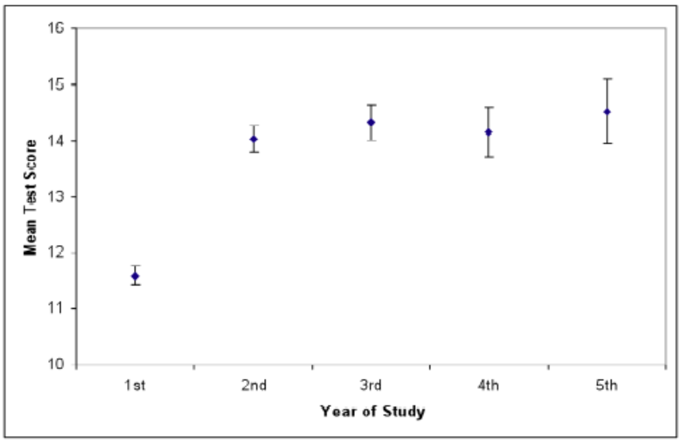

Fig 1: Mean test score (out of 23) for Edinburgh physics students as a function of cohort year

Data-handling Skills

The intention is that students who... identify weaknesses in their understanding can be directed to... resources... Thus, skill gaps can be addressed as well as diagnosed.

In addition to developing and validating our diagnostic instrument, we are also generating additional learning support resources which will be made available on-line. The intention is that students who take the test and identify weaknesses in their understanding can be directed to these resources for additional explanations, worked examples, practice problems, etc. Thus, skill gaps can be addressed as well as diagnosed: this is particularly important for experimentally-related concepts such as those covered by the test, since for reasons of logistics supplementary laboratory classes can be disproportionately difficult to schedule (in comparison to additional tutorials or workshops, for example).

In addition to developing and validating our diagnostic instrument, we are also generating... learning support resources

The on-line supporting resources are designed to be as interactive as possible, rather than simply textbook-like restatements of ideas and concepts. We have used our Aardvark content management system to provide the infrastructure to create a short, self-contained online course that targets the most common sources of error we identified from the pilot evaluation. The structure of each page include worked examples, key points, dynamic content elements and a series of 'test your understanding' problems at the end of each page, both MCQ format and tutorial and PBL-style problems.

The learning resources have been developed over the summer of 2010 and are currently undergoing final checking. They will shortly be available from the project website on our group pages.

Dissemination activities
The test and outcomes of the pilot investigation have been widely disseminated. The project design, development and evaluation, and the preliminary findings from the trial deployment, have been submitted as a paper to Physical Review Special Topics: Physics Education Research, in order to enhance the project's visibility to the national and international audience.

Project continuation
As a result of participation in the trial phase of the development project, at least six of our partner institutions are planning to repeat the deployment of the test to measure the stability of class performances or to try to track any improvements. A number of these institutions are also using the outcomes of the trial deployment to inform proposed revisions to their lab teaching and/or curriculum structure. At least two departments plan to use the test and materials for lab demonstrator training, having identified this as a potential weak link.

As a result of presenting the project at the Summer Meeting of the American Association of Physics Teachers in Portland, Oregon, as of this time we have received inquiries from three institutions in the United States, one in Israel and one in Denmark about potentially deploying the test with their students. We are in early stages of discussion but anticipate that one or more of these plans will develop into a more extensive international collaborative project.

The test instrument is currently available from our group website <bit.ly/EdPER>. ■

A number of these institutions are... using the outcomes of the trial deployment to inform proposed revisions to their lab teaching...

Pop-Up

Development Project Report

Pop-Up: Perceptually and Pedagogically Effective Visualisation of 3-Dimensional Molecular Structures

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Introduction

Many topics in chemistry require understanding of 3D (Dimensional) structures. Molecular visualisation thus has the potential to profoundly transform chemistry instruction (at all levels of education). To make the molecular visualisation interactive where the student is able to change the viewpoint and quickly appreciate the 3D structure of the molecules, a simple lighting effect of low computational complexity is often used. This simplification, however, makes it difficult to interpret the rendered images since the 3D structure is unclear (see Figure 1 'Before'). We instead propose a perceptually effective lighting effect to make the 3D structure to pop up while maintaining the visualisation at interactive rates (see Figure 1 'After').

This project aimed at providing open-source computer software to visualise 3- dimensional molecule models with the proposed lighting effect and relevant learning material. In achieving the goals, we have paid attention to the following key points:

1. While most of existing molecular visualisation software use a local lighting model with undesirable 'flattening' side effects, our approach effectively employs a global lighting model that better reveals the 3D structure of molecules (see Fig. 1).
2. We have made sure that only consumer-level PCs are necessary to run the proposed molecular visualisation and that only free tools and standard formats such as JAVA, VRML (Virtual Reality Modelling Language), and PDB[2] (Protein Data Bank) files are needed. This low-cost approach will provide a highly valuable, and cost effective, educational tool for the teaching of molecular structure. This contrasts with other application of molecular visualisation to chemistry education, which relies on commercial software, 3d max[1].

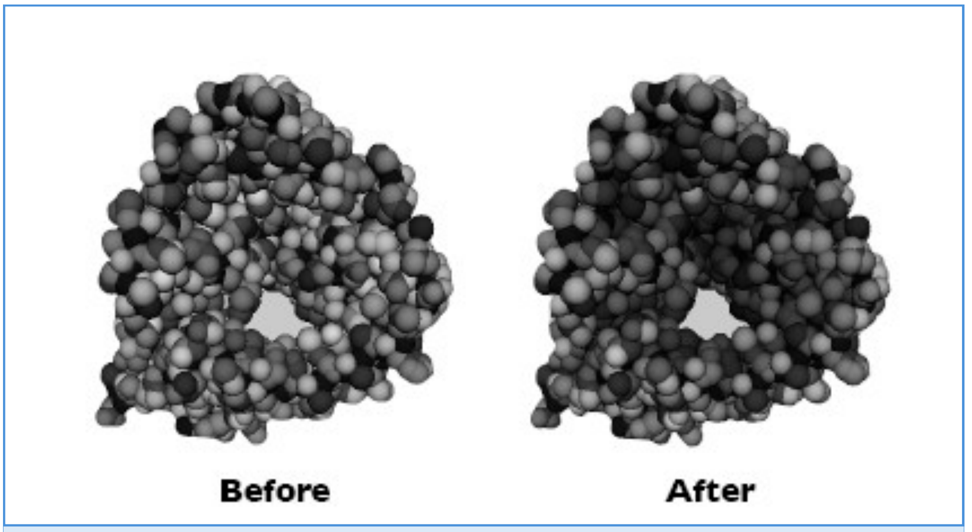

Figure 1: Molecular visualisation with perceptually effective lighting models. (Before) with a conventional lighting model, the molecule appears 'flat'; (After) with the proposed effective lighting model, the molecule appears to have 'depth', thus, better reveals the 3-dimensional structure of it

We have made sure that only consumer-level PCs are necessary… and that only free tools and standard formats… are needed

Pop-Up

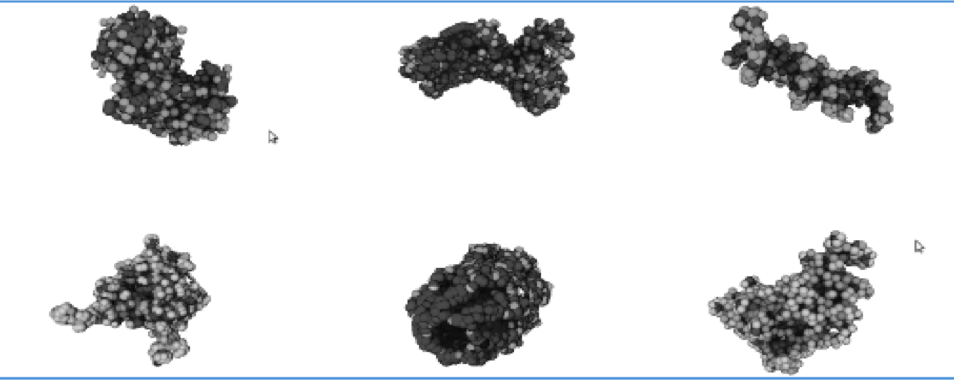

Figure 2: Selected rendering of large molecules based on the proposed ambient occlusion software. Note that 3D spatial structure of the molecules are well visualised, especially, the concave parts of the molecules; this would be difficult to achieve with conventional molecular visualisation methods

A website dedicated to this project has been constructed, Rapid AO... provides full 3D models...

Outcomes of project

We have completed the software (written in JAVA) that reads a PDB file of a molecule, and writes a VRML file that contains a 3D model of the molecule with the proposed global lighting effect called Ambient Occlusion. VRML is a standard file format for representing 3-dimensional interactive vector graphics, which can be rendered using a standard web browser[4].

In our informal evaluation, we often get comments that, compared to the conventional approaches, the proposed lighting effect not only better reveals the 3D structure of molecular, but also can be aesthetically more pleasing; see Figure 1 and 2.

Dissemination

A website dedicated to this project has been constructed, Rapid AO[3]. For example molecules, we used biological macromolecules, especially those featured in Molecule of the Month[5]. Note that our website provides full 3D models of these molecules (with the proposed light effects) while the Molecule of the Month website only provides 2D images. The software is available for free.

Future

New course material based on the proposed molecular visualisation is under construction for chemistry undergraduate students (by Anna Croft); in particular, more thorough evaluation will be pursued.

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4. VRML Archives <www.web3d.org/x3d/vrml/>
5. Molecule of the Month <www.pdb.org/pdb/motm.do>

... we often get comments that ... the proposed lighting effect not only better reveals the 3D structure... but also can be aesthetically more pleasing

Pedagogic Toolkit for Creating MCQs

Development Project Report

The Development and Implementation of a Pedagogic 'Toolkit' for Creating Multiple Choice Questions (MCQs) for use within a Forensic Science Teaching Environment and to Support Forensic Practitioner Work-Force Competency Testing

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Multiple Choice Questions (MCQs) are a type of objective test question which involves an answer(s) to be chosen from a list of possible responses[1]. MCQs are commonly used within physical sciences education for both summative and formative assessments as they are a practical and efficient means of assessing large groups of students[2]. Much research has been completed upon MCQ use, design, management and implementation and due to this there are an abundant amount of resources that can be used by academics if they wish to use this type of assessment within their own teaching.

Aims and Objectives

This project ultimately aims to develop a series of resources (a 'toolkit') for the development and implementation of MCQs for academics that teach forensic science to undergraduate and postgraduate students. These resources will include the generation of a bank of example MCQs, guidelines for MCQ management and an associated workshop in the design and implementation of MCQs in forensic HE assessment.

To enable these aims, the following tasks were carried out:

- Research into MCQ design and pedagogy, focussing on areas that have previously used MCQ for assessing competency and applying these to forensic teaching practices.
- A survey into the use of MCQ questions within current forensic science modules at Staffordshire University
- Development of learning outcomes and assessment criteria for MCQ tests for a forensic teaching environment including consideration of practitioners requirements.
- Contribution to a large scale MCQ testing scheme for forensic practitioners and provide Forensic Science Society (FSSoc) with advice, recommendations and guidelines in the design and implementation of MCQs in their competency testing scheme. Observations of the potential problems that can be encountered when designing MCQs in forensic science topics.

Research Approach

Initial exploratory research was conducted into the use of MCQs in forensic science based modules at Staffordshire University. In total, 29 modules (8 at level 4, 11 at level 5 and 10 at level 6) were explored in terms of the quantity of any formative or summative assignments that contained MCQ questions. In class use of MCQs for formative purposes and Blackboard quizzes were included in the survey. Assignments that were part formed from MCQs were also counted.

Utilising current literature into MCQ development, particularly Bloom's Taxonomy, learning outcomes and assessment criteria have been developed for MCQ testing of forensic practitioners. These have been developed with the FSSoc so that they are appropriate methods for the testing of any individual engaging with forensic science.

Outcomes of Project

Survey of MCQ Use in Forensic Science Modules

To ascertain where MCQs are used within the forensic science teaching at Staffordshire University, discussions with the module leaders of forensic science related modules were carried out. These discussions identified how MCQs were used as either learning and teaching aids or as assessments.

Development of Learning Objectives for Testing Competency in Forensic Science Skills

Prior to the generation of the MCQs for the testing scheme, learning outcomes were required. As stated by Collins[3], these learning objectives should be written in terms of specific learner behaviour and should define the important skills and knowledge required to be tested.

Findings and Interpretation of Pilot Competency Test

When designing the MCQs, it became apparent that a designer should *not* become bogged-down with attempting to make every question test higher cognitive levels. There is a tendency, once fully aware of the potential to test skills such as problem solving, to design all of the questions to meet this level. In reality, the level must take into account the subject matter as well as the level of understanding that is required from participants. For example, the general forensic science questions in the pilot test were centred mainly on factual issues such as expert witness duties, continuity of evidence and court conduct. As stated by MCQ researchers such as Glaser[4] and McCoubrie[5], to ascertain expertise in this type of general area of forensic information, demonstration of pure knowledge of a domain is 'the single best determinant of expertise.'

Pedagogic Toolkit for Creating MCQs

MCQs are commonly used within physical sciences education for both summative and formative assessments as they are a practical and efficient means of assessing large groups of students.

MCQ Management
When designing MCQs that must potentially stand-up to scrutiny in a UK Court, any quality assurance procedures used must be transparent and easy to follow by those considering it. When designing the MCQs for the forensic practitioners, it became apparent that when there are a large number of questions that need to be reviewed and updated by a group of designers, a continuity trail is desirable. This trail can most easily be provided by utilising a database which states any changes to questions that have been made, the name of the designer making the changes and when and how the questions have been used.

MCQ Examples for Academics
In light of the knowledge and experience gained in designing MCQs for the FSSoc competency testing scheme, a set of example questions that test the different levels of cognitive thinking described in Bloom's Taxonomy. These examples will be made available via the Higher Education Academy.

MCQ Workshop
The example set of forensic science MCQs are a useful tool for academics to use within their teaching but do not show how they are constructed and the rules that should be enforced during design. To educate forensic educators an MCQ design and implementation workshop has been created. The workshop addresses issues in the design, development, implementation and marking of MCQs in the field of forensic science.

Overall Conclusions
Observing an MCQ testing scheme for forensic practitioners to provide information and ideas for academics wanting to use this assessment method in their teaching has been invaluable. Higher Education is constantly aiming to develop assessment types which are not only robust but also so that their actual creation may be mapped in terms of quality control and validation. In examining a system which must be sufficiently robust to stand up in a court, the smallest details in design are crucial, and therefore most useful for academics trying to create MCQ tests for students. A limitation of this study has been the small cohort of participants that took part in the tests to date. This project will develop as further MCQ tests are generated in forensic subject areas other than forensic podiatry. In addition to this, MCQ tests will be incorporated into two level 5 module assessments. The effectiveness of this assessment type at this level in forensic science modules will be evaluated by comparison of results with past years results and by analysing the students experience of the assessment through questionnaires. Further quantitative analysis of the responses from the initial podiatry MCQ testing scheme in conjunction with future testing rounds will be carried out to allow any trends in responses to be indentified, for example, the identification of any stem and distractor combinations which have a higher success/failure rate.

As an assessment process for forensic practitioner competency, MCQs have demonstrated that they can be robust if designed with knowledge of the requirements of the expected audience and of the design philosophy of MCQs which appropriately test hierarchical cognitive learning.

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Development Project Report

Effectively Engaging Forensic Science Students and Employers in Developing Graduate Employability

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Engaging Forensic Science Students

Following the revalidation of the BSc Forensic Science programme at Lincoln in 2008 it was decided that a series of employability workshops would be run in conjunction with Opportunities@Lincoln, the university's careers service and part of Enterprise@Lincoln the university's central department for employer engagement and business services.

The cornerstone of this programme is the effective use of relevant employers to help inform students about opportunities, career preparation and necessary employability skills. It soon became clear from student and employer feedback that our employability workshops were of variable quality and success.

The cornerstone of this programme is the effective use of relevant employers to help inform students about opportunities, career preparation and necessary employability skills.

It is with this feedback in mind that we intended to find out what students and employers expected from employability workshops. Could we improve the student experience? Could we encourage better engagement between employers and students?

We surveyed 220 students of all levels from the Universities of Lincoln and Kent to explore the problem in detail. The questions were designed to collect qualitative data relating to career aspirations and general interests. These questions included

How clear are you on the type of job/ career you would like to apply for once you have completed your degree?

and

Please list three career areas that interest you in order of preference

We also included quantitative questions that explored students' perceived readiness for employment. For example

To what extent do you agree with the following statement?
Scale of 1-5 (1 strongly disagree – 5 strongly agree)

I can target my CV and covering letter to my career area

The survey shows that most students do not see forensic science as a vocation. Some see it as an opportunity to study both chemistry and biology: others see it as something interesting to study but not to follow up in a career context. Career aspirations from the study group include forensic science, teaching, writing, general science, humanities and business. It should be recognised that too many employability workshops aimed at careers in forensic science are liable to be met with boredom and poor attendance.

The survey shows that most students do not see forensic science as a vocation… not to follow up in a career context.

Engaging Forensic Science Students

Career aspirations from the study group include forensic science, teaching, writing, general science, humanities and business.

The quantitative survey also shows that employability workshops are seen as useful for those that attend them but many of the technical aspects such as CV writing and job application are of little interest without an employment opportunity to chase down. Typically a student requiring a part time job during term time would ask to have personal training in these technical aspects. Students need to be enthused by a range of career options and types of employer. Once they are enthused they become much more receptive to the technical aspects of applying for jobs.

...from informal discussions it would seem that employers prefer to meet with students in small numbers, in an informal setting, perhaps in the workplace.

We adjusted our employability workshops to take account of the survey results. For example someone from the food industry came to talk about career opportunities. Only 15 out of 65 students turned up. The talk became an interesting and informal discussion between the employer and the students. Students and employers became engaged. The small numbers were disappointing but the quality of the engagement was high.

We held an event entitled Science Futures where we invited a range of employers to meet with students in an informal setting. Students were able to make valuable contacts by speaking informally with employers. This was followed up by using student focus groups to find out what sessions were most effective throughout the year. Students reported that they appreciated the opportunity to be exposed to career areas they had never considered before. As a result of this they have been encouraged to contact the University of Lincoln's career service and have followed through with job applications. Students also found that informal contact with employers had increased their confidence.

We also sent out a survey to employers. At the time of writing we are still waiting for the survey to be completed. However, from informal discussions it would seem that employers prefer to meet with students in small numbers, in an informal setting, perhaps in the workplace. Employers often get negative impressions from some students in large lecture theatres and are sometimes intimidated. Furthermore such meetings do not tend to generate real engagement.

It seems clear from the results so far in this study that the best approach to fostering student-employer engagement is to expose students to a wide range of opportunities and employers as they develop through their course. They may not all become forensic scientists but most will make informed career choices and hopefully go on to enjoy successful careers. ■

...the best approach to fostering student-employer engagement is to expose students to a wide range of opportunities...

Enhancing Literature Review Skills

Development Project Report

Enhancing Literature Review Skills within Forensic Science Undergraduate Project Work

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Introduction

All science students engage in project work, normally in their final year of study. A crucial part of that exercise is in understanding the context of and being able to evaluate their work through a sound knowledge of the relevant literature. Despite being able to identify some publications of relevance, students frequently fail to fully assimilate previous work and to acquire sufficient understanding to be able to properly evaluate the results of their own study. This project aims to enhance the skills of final year forensic science students in reviewing and critically appraising the primary literature on a specified topic using techniques of concept mapping.

Concept maps and literature review

Concept maps facilitate the organisation and extraction of key information from very many sources with a view to helping the learner to assimilate the material in a structured and systematic manner[1]. This is achieved by representing concepts as nodes on the map and relating these by cross-links. The combination of two nodes and a cross-link produces a proposition which embeds knowledge within the map. Thus the completed map provides a systematic representation of this area of knowledge. Any such map is essentially work in progress and may be edited and expanded according to one's current understanding of a topic. In this project the concept map is constructed and developed through the student's own exploration of the literature. It may then be used to as a structured resource for both retaining this knowledge and as a framework for producing a written review of the research topic.

The Visual Understanding Environment (VUE) software

At the start of this project, tools to facilitate the production of concept maps were evaluated and the VUE package from Tufts University selected[2]. This has the benefit of ease of use as well as the facility to link in directly any relevant publications either as text-files, images or as web-links to journal websites as well as the users own notes on any particular aspect. These may be associated directly with either nodes or cross-links and allow a complete organized electronic resource to be assembled for each research topic. The package is also freely available on-line. Using VUE three exemplar concept maps on distinct forensic topics, typical of those often chosen for projects or dissertations, have been prepared and were later used as reference materials for the students working on their own maps. These are on fingerprint science, the forensic examination of inks and alcohol in the body.

Reviewing student perceptions

As part of this project the views of the student cohort were surveyed at two points. At the start, their previous experience and current expectations of preparing a literature review were surveyed. At the end of the project these issues were revisited and the students' own evaluation of their work was recorded using a further questionnaire. Since students at Keele study a compulsory dual honours degree programme for the first two years of their course, some had experience of carrying out a literature review in their other subject while some had not done this before. A key finding from this survey was that students appear to underestimate the difficulties in such work if they have not experienced it before while those with previous experience are more realistic on the challenges in carrying it out. They was also a view that the literature searching and evaluation was a more straightforward task than the later stages of extracting relevant information, assimilating it and compiling the report. This was true whether or not the students had previous experience; only the degree of difficulty they anticipated was different.

Concept maps facilitate the organisation and extraction of key information from very many sources with a view to helping the learner to assimilate the material...

Enhancing Literature Review Skills

The majority of the students found the sessions on literature searching techniques and concept maps either very useful or useful ...

Training lectures and workshops
The main activity of the project was the delivery of three sessions at the start of the year which were designed to prepare the students for the work on their own literature reviews. The first focused on the mechanics of exploring the literature using the *Web of Science* and other facilities. The second examined the principles behind concept maps and their application, together with examples of how they may be constructed using the results of literature searching. The final presentation explained the use of VUE. It discussed how concept maps may be assembled and displayed, how links may be inserted to bring up relevant files, images or web-links using this package. Many illustrations are included to demonstrate these features. These presentations will be available to the community as part of the output of this project. Over the weeks following these presentations students were given individual support where requested in working on their draft maps. Following electronic submission, the maps prepared by students were evaluated by myself and the literature reviews that they submitted towards the end of semester one, were assessed in our usual manner which included an interview examination.

Project Evaluation
The project has been evaluated both by the students and by myself. The majority of the students found the sessions on literature searching techniques and concept maps either very useful or useful while around half felt the same way about the lecture on using VUE. A large majority felt that concept mapping overall had had been either helpful or very helpful in preparing their review. Interestingly a similar question on the guidance provided by their supervisor at this point showed that concept mapping was seen as of significantly more benefit to the preparation of the review! Among the unprompted comments some students admitted that they should have started using concept maps earlier in their preparation for the review. The overall perceptions of the students in executing the literature review was revisited at this point and once again it was found that the experience tends to educate the students in the difficulties in carrying out what is a fairly complex task rather than making them feel more confident about it. From the point of view of the lecturer, it was clear that the students understood the basic ideas and had few problems in working with the VUE software. The most able students were able to use this approach effectively and produce good maps. For many students, the identification of key concepts and constructing proper propositions as well as organising a map where there were many inter-related concepts, were more challenging tasks. Many did not refine their draft maps sufficiently or include the links to their references as extensively as was expected. However it is intended that concept mapping will be used again with next year's cohort and delivery will be refined to enhance the students' engagement with this approach. Consideration will be given to introducing the concept mapping method in an earlier year of the course so that students are in a stronger position to apply it to their project work in the final year. The materials developed in this project will be available through the UK Physical Sciences Centre website and the author welcomes any feedback from others who may wish to implement this approach in the future.

I am grateful to Dr Chrystelle Egger for useful discussions and contributions in the planning of this project.

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Consideration will be given to introducing the concept mapping method earlier... so that students are in a stronger position to apply it to their project work in the final year.

Green Chemistry

Development Project Report

Green Chemistry: development of an educational board-game

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The aim of this project is to develop a board-game that illustrates "the twelve principles of green chemistry."[1] The game is designed with first year undergraduate students in mind, and will offer an opportunity for tutors to adopt an unusual context-based teaching method.

By learning through game-play, I hope that students will be engaged and find the experience enjoyable in a social context, perhaps improving group cohesion, as well as reinforcing the educational principles modelled by the game.

I envisage tutors using several copies of the game to accommodate their group in a workshop environment, or as an alternative to a laboratory session, with students playing in groups of up to six. Post-game discussions will highlight some of the technologies featured in the game to introduce the green chemistry principles.

Games and education

Games are used in many educational fields[2,3] as well as in training within industry or other organisations,[4,5] using either board or computer platforms. The use of games in science[6] is more restricted, with availability being particularly limited in the chemical sciences. Thus I wanted to design a game for chemical sciences students that is simple enough to learn quickly and is engaging to play, whilst not being trivial by retaining real educational value.

Green chemistry is a suitable game theme. Players take the role of industrialists and make decisions on how to manage their technology development (e.g. better synthesis routes), waste stream abatements and energy requirements to optimise their table-top product manufacturing schemes with the aim of maximising their profits by the game end.

The game

There are two key requirements for this game, but there is tension between these needs. As a game, it must be playable and engaging otherwise it will be difficult to enjoy. As an educational resource, it must be complex enough to model the theme to some extent, and the decisions players should directly relate to the green chemistry principles featured.

The game as designed consists of 7 rounds of four steps. In the first step, players can choose to purchase a new technology (e.g. production of adipic acid) from a choice, ultimately, of twelve. The technology shows the raw materials and chemical plant required depicted on a playing card. The product value (income) and wastes produced are also depicted. The reverse of each card a brief written summary of the chemistry involved.

In Step 1, players can alternatively invest in upgrading a technology they already own to its improved (advanced) status. Raw materials, energy costs and waste streams change to reflect to incorporation of green chemistry into the improved manufacturing process. Again the card reverse briefly outlines the chemistry.

In Step 2 of the round, each player acquires and pays for the raw materials and energy required for their product. Chemicals are abstracted to defined units of bulk and special chemicals represented by coloured tokens (e.g. wooden cubes). Similarly, energy is purchased with a variable price reflecting a changing energy market.

In Step 3 players process their raw materials into product. They return the feedstock cubes to the supply, note the energy consumed, gain income from their product and acquire bulk and special waste

By learning through game-play, I hope that students will be engaged and find the experience enjoyable…

Green Chemistry

Templates and guidance notes will be available to allow tutors to incorporate their own technologies of interest into the game.

products, again represented by coloured tokens. Step 4 of each round is where players must dispose of their wastes, either by purchasing treatment plant to eliminate or convert waste cubes or by paying to remove them to a market where prices increase throughout the game. Players must anticipate their waste production and act to abate or eliminate their waste streams.

Energy consumption can be played using a simple mechanism, or using a more elaborate model representing CO_2 emission limits and trading.

After seven rounds, players will have one or two technologies, usually having advanced at least one of them, and installed waste treatment and/or energy recovery to optimise their income. The wealthiest player wins. Each round takes 5 -7 minutes to play, so the game should be completed inside an hour.

Outcomes

The game components and rules will be available via PDF download (September 2011) to allow tutors the print multiple copies for their group; cheap sources for other game components will be listed. A short how-to-play video will be made available.

Templates and guidance notes will be available to allow tutors to incorporate their own technologies of interest into the game. I hope the game will continue to evolve with a wide range of green chemistry technology card becoming available. I will investigate the feasibility of producing inexpensive hard copies of the game given sufficient interest.

The game will be presented at the Variety in Chemistry Education conference 2011. Delegates will have the opportunity to learn and play the game and discuss it's design, role and function with me.

I thank the UK Physical Sciences Centre for funding this project. I also thank students, family and friends who have helped with play-testing. Special thanks to Daniel Rawlins who has helped significantly with game development.

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Energy consumption can be played using a simple mechanism, or using a more elaborate model representing CO_2 emission limits and trading.

Peer Assisted Learning in Physics

Development Project Report

Peer Assisted Learning in Physics – do students think it works?

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Aims of project
"Peer assisted learning" takes many forms. In the School of Physics and Astronomy at the University of Glasgow it is used in the form of "Peer to Peer" (P2P) tutorials: students in levels 3, 4 or 5 of their degrees act as tutors to whole class groups of level 1 or 2 students. There are four tutorials per academic year, per level. At each tutorial there is roughly 10 tutors for a group of up to 120 students. These students are split across three rooms – one lecture theatre and two classrooms.

The aims of the P2P tutorials are as follows:

- A: Assist with student learning/revision of physics.
- B: Help to integrate level 1 and 2 students into the School of Physics & Astronomy through communication with level 3/4/5 students.
- C: Give level 3/4/5 student-tutors an opportunity to develop/improve their teaching skills and their understanding of the basics of physics.

These tutorials have been running for several years now, and anecdotally have been considered a success.

These tutorials have been running for several years now, and anecdotally have been considered a success. Students' views of them have never been investigated in any detail, though. This project addressed this, and more. The goals of the project as are:

- Determine the attitudes towards, and experiences of, the P2P tutorials of *students* in the School of Physics and Astronomy.
- Determine the attitudes towards, and experiences of, the P2P tutorials of *student-tutors* in the School of Physics and Astronomy.
- Assess how well the aims of the P2P tutorials were being met, and hence identify any areas of improvement that would make the P2P tutorials a more effective learning experience.

Student-tutor results
The student-tutors completed on-line surveys, using Survey Monkey. A separate survey was completed after each tutorial they took part in. These surveys were designed to encourage the tutors to reflect on their own experiences during each of the tutorials they took part in.

Why did they choose to be student-tutors?
26 level 3, 4, and 5 students volunteered to act as student-tutors during 2010-11. At the beginning of the project, they were asked why they had chosen to take part. There was a range of responses, which broke down into three key areas:

- Improving their own skills-base (e.g. through improving their communication skills, or through improving their knowledge of fundamental physics).
- Enjoyed teaching/tutoring.
- They wanted to be of help, either to their fellow students, or to the School as a whole, or both.

Student-tutor attitudes and reflections
After each tutorial, the student-tutors were asked to comment on four statements about their attitudes towards, and experiences of, the P2P tutorials. On a scale of Strongly agree/agree/neutral/disagree/strongly disagree, the student-tutors consistently agreed or strongly agreed with the statements throughout the course of the project. The statements were:

- Tutoring students in lower levels helps with my understanding of physics.
- Acting as a tutor made me feel more confident in my understanding of physics.
- I got a feeling of satisfaction from tutoring other student.
- Acting as a tutor made me feel more a part of the School of Physics and Astronomy.

Reflections on their experiences varied from brief summaries of what happened in the tutorials, to more in depth reflections on their experiences. The general view expressed was that the tutorials were successful, though just how successful depended on the willingness of the level 1 and 2 students to take part.

Key issues they reported included:

- Concerns over their own performance – Were they prepared enough? Were they approachable enough?
- Best format for the tutorials – Should questions be tackled on an individual basis, or in groups?
- Best format for questions – Standard coursework type, or more discursive?
- There is a difference between knowing a topic, and being able to explain it to someone else.

Student results
Paper survey questionnaires were completed by 109 students in level 1 and level 2 physics at the end of the P2P tutorials in late semester 2 of academic year 2010-11.

Peer Assisted Learning in Physics

The students felt it was useful to have the tutorials in their timetable, with them improving their understanding of coursework through discussions with their peers, and the tutors.

Student attitudes to the P2P tutorials
Students were asked to reflect on their experiences of the P2P tutorials. Based on the results of these questions, the strengths of the tutorials were as follows:

- The tutorials were useful.
- The tutorials helped the students' understanding of their physics coursework, both through the tutorials themselves and in terms of the opportunities the tutorials provide to discuss that coursework with the classmates.
- The tutorials helped their confidence with the coursework.
- The tutors provided valuable help. (The level 2 students felt this particularly strongly. Their tutors had been in the job longer, suggesting that the tutors were getting better with experience.)

... this project has confirmed that the P2P tutorials are an effective component of the undergraduate teaching...

Where the tutorials were less successful, though, was in the area of integration of the level 1 and 2 students into the School as a whole. This was one of the key aims of the P2P tutorials, and whilst it was being achieved for the student-tutors, the students did not feel particularly strongly that this was the case for them.

The students were asked to rank – from a prescribed list – the main reasons that the P2P tutorials were valuable. In descending order, they ranked them as follows:

- They help with my understanding of key course concepts.
- They provide a chance to discuss coursework with classmates.
- They provide a break from lectures.
- It is less embarrassing to ask questions of students than lecturers.
- They provide a chance to meet students who were in our shoes not so long ago.
- They provide a chance to learn more about the reality of being a physics student.
- They make studying physics more enjoyable for me.

The final question in the survey asked the students to identify areas for improvement that they would target if they were in charge of the P2P tutorials. There was a wide range of responses, which fell into the following categories:

- *Format of tutorials* – e.g. tutors should go through solutions on the boards for the whole class, and for the reduction of group sizes and/or more tutors.
- *Format of questions* – e.g. more tutorials, providing the questions to attempt further in advance of them, making sure solutions were then made available after the tutorials.
- *Administration of tutorials* – e.g. they should be structured to encourage group work, or to tie in better with the workshops and/or examinations they were assessed in
- *Performance of tutors* – e.g. get tutors to interact more with students, and to be better prepared.

Conclusions and future work
Overall, both students and tutors reported that the P2P tutorials were a positive experience. The students felt it was useful to have the tutorials in their timetable, with them improving their understanding of coursework through discussions with their peers, and the tutors. They felt that the tutorials improved their confidence in their work, and that the tutors themselves made a valuable contribution to their learning.

The tutors had taken part in the scheme to improve their own skills and to assist both younger students and the School. Their reflections on the tutorials show that these goals were met.

The students did not agree that these tutorials made them feel more a part of the School. It is possible that this is a result of the relatively small number of tutorials that run each year – 4 through the course of an academic year in each of the two classes studied. It is interesting to note, though, that the tutors did feel that the tutorials helped them feel more a part of the School.

Overall, then, this project has confirmed that the P2P tutorials are an effective component of the undergraduate teaching at the School of Physics and Astronomy. Whilst they are not perfect, they were viewed positively by students and tutors alike. This project has allowed a clear picture of what works to be created, and provided clear guidance for what needs to be adjusted to improve this already positive situation. ■

Developing a Context-Based Laboratory

Development Project Report

Research Informing Teaching: developing a context-based laboratory

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Practical skills are crucial for success in science. At the University of Leicester we aim to give our students the opportunity to develop their scientific curiosity by engaging in contextualised open-ended laboratory exercises which challenge and stimulate. By working in small groups to tackle unfamiliar open-ended experiments, apply their chemical knowledge, and interpret complex data we aim to produce students who will go into their final year project armed with a range of skills which will make them more immediately effective in a chemistry research environment. To that end, a series of extended investigation practicals based around the themes of physical, analytical, materials, forensic and green chemistry have been developed for Level 3 MChem students which encourage a greater level of student engagement.

The development of the module began with a survey of all undergraduate students at the beginning of their 3rd year (i.e. students that had completed two years of taught practical courses) to gain feedback on the courses that they had so far covered. Currently, the majority of physical and analytical chemistry experiments are formulaic in nature and focus on the acquisition of key skills. In these sessions there is a limited amount of time available for students to collect sufficient data for interesting analysis or to conduct repeat observations. As a consequence, there is anecdotal evidence to suggest the majority of students prefer synthetic lab classes where experiments are carried out over several lab sessions. The survey results supported these findings showing that most students have enjoyed synthetic practical the most, and that when given the opportunity, they enjoyed working in groups. Most students said they liked to be given guidance on how to conduct the experiment, and as expected the weaker (BSc) students felt more comfortable when they had step-by-step instructions to follow. Interestingly, when this survey was conducted, no MChem students recorded that they were interested in further study such as PhD, this is something we hope to encourage amongst our group of brightest students, and one of the aims of the project was to introduce these students to the 'research environment' and to stimulate their interest in carrying out in-depth research projects in the future.

New extended investigation experiments on the theme of forensic chemistry were incorporated into the Level 3 MChem *Advanced Chemistry Practical* course which ran during semester 1 (7th October – 9th November 2010).

Both new forensic experiments concerned the enhancement of latent fingerprints on different types of metal surfaces. Typically, these types of fingerprints are very difficult to acquire and there is a low success rate for using them in criminal investigations for prosecution. Therefore, any means of extending the capability to obtain fingerprint information is of considerable significance. In both experiments, students deposit eccrine, sebaceous and greasy fingerprints on a range of metal surfaces, and each team decides on pre-treatment conditions of the samples e.g. how long to leave the sample before enhancing the print, placing the samples under different conditions such as salt water/acid/burying in soil/hot oven etc.

In the first experiment, students electrodeposit polyaniline onto a stainless steel sample which has a fingerprint on it. This method is spatially selective: the polymer deposits onto the clean metal surface between fingerprint ridges to generate a negative image of the fingerprint deposit. The experiment was designed because investigation of fingerprints on stainless steel surfaces is required in view of their widespread use in common objects (handles, tools, knives) of forensic relevance. In this experiment, students learn voltammetry and chronoamperometry techniques. Both sebaceous and eccrine prints are studied (from various donors) and the stainless steel samples are subjected to different pre-treatment conditions which simulate various environments.

(A) (B)

Figure 1: (A) Optical Microscope (x5) image of a greasy fingerprint deposited on a copper plate enhanced by immersion in ionic liquid for 30 seconds. (B) SEM image (x50) of same sample showing the contrast between the darker areas (fingerprint ridges) and the lighter areas of deposited silver

Developing a Context-Based Laboratory

In the second experiment, electroless deposition was employed to enhance fingerprints from copper and brass surfaces (e.g. bullet casings). Again, current methods for enhancing fingerprints from these substrates have a low success rate. The students compared both aqueous and ionic liquid systems for enhancement of fingerprints. Immersion time in each deposition solution was varied and samples were analysed by ESEM/EDAX. Students had plenty of lab time to optimise the deposition conditions, and carry out detailed analysis including optical microscopy, EDAX mapping, and AFM (see Figure 1). These experiments allowed undergraduate students to work directly alongside researchers, and data generated fed into the ongoing research project.

In addition to the new experiments which the MChem students experienced, experiments tying together the themes of nanoscience and green chemistry are under development. Various methods of synthesising gold colloid have been investigated (room temperature synthesis, synthesis at 100°C, and via pH control) and the stability of the colloid has been investigated using UV-Vis. TEM images were gained which showed that the colloids were generally monodisperse (see Figure 2). The addition of protein to the gold colloid was investigated, and TEM data suggests that protein was successfully attached to the surface of the colloidal particles. The second nanoscience experiment involves the 'green' synthesis of ZnO nanomaterials using anti-solvent injection. ZnO plays an important role in the electronics industry and various synthetic routes have been investigated to prepare specific nanostructures. So far, the materials produced have been analysed using FEGSEM, and TEM data will be collected. These new experiments will be incorporated into the course in October 2011.

Conclusion

The new experiments proved to be enjoyable for the vast majority of students. The forensic context helped students engage with the research topics, generating enthusiasm and encouraging students to produce well written extended reports. feedback quotes:

> *"It gave me a chance to work with up-to-date techniques, which have just been introduced to the real scientific world"*
>
> *"Most relevant to my course and I found it interesting because we were doing something new"*
>
> *"It was interesting investigating the different effects the different environments had on the fingerprint and I liked using the SEM"*

For the first time, physical chemistry extended practical was run at the beginning of semester 1, rather than at the end of semester 2. By starting with team based open-ended extended experiments first, we've noticed this really kick-started the students into working at a consistently higher level and for the first time ever, all students completed the synthetic practical which came afterwards in record time.

Anecdotal evidence shows huge benefits to running the course this way around. This module will continue to run in this slot at the University of Leicester. It is apparent that the informal interaction between students and researchers helped students build the confidence to go further in the study of physical science.

This module will continue to run... informal interaction between students and researchers helped students build the confidence to go further in the study of physical science.

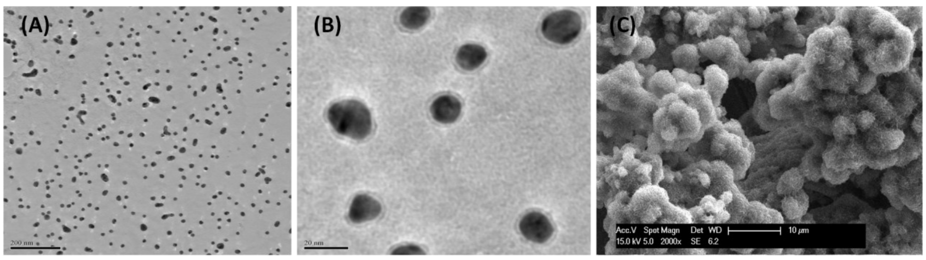

Figure 2: (A) TEM image of gold colloid synthesized by the Turkevitch method (at 100°C), (B) TEM image of gold colloid stabilized by protein, (C) FEGEM image of ZnO nanomaterial produced by anti-solvent injection

Web-based Interactive 3D Simulations

Development Project Report

Web-Based Interactive 3D Simulations of Stereo- and Enantioselective Organic Reaction Mechanisms

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Interactive simulations are an increasingly important component of teaching and learning in the Physical Sciences. They can be used very effectively in traditional lecture demonstrations but are also invaluable for individual study in a personalised learning environment. Computer generated simulations, with which the viewer can interact, offer the opportunity for a much more informative, enjoyable, learning experience. Until very recently, they required specialised software but now a high quality experience is possible using only a web browser and the free open source molecular viewer applet Jmol <jmol.sourceforge.net/>. This entirely web-based approach can be integrated seamlessly into both resources and questions inside VLEs. Jmol has recently undergone major development with the introduction of new features that are particularly powerful in a didactic environment.

Introduction

Stereo- and enantioselective reactions are at the core of modern organic synthesis. Understanding the origin of the crucial selectivity depends on visualisation of interacting three-dimensional molecular structures, which is extremely challenging with our current methods of representing them in textbooks, on blackboards, screens and paper. Curly arrows unify organic chemistry, and are essential to the solution of problems but still require “interpretation” to provide a clear understanding of molecular motion during bond-forming and breaking events. A much more profound understanding of reaction mechanisms is possible by interactive inspection of animated reaction sequences which progress from starting structure via the transitions state to the products with associated changes in distance, bond type and angles.

Having demonstrated simpler three-dimensional animated reaction mechanisms developed for ChemTube3D in undergraduate lectures and UK Physical Science Centre supported departmental seminars in recent years, it is clear the impact they can make and the contribution to learning that results. Therefore we proposed the creation of a collection of 3D interactive simulations of important stereo- and enantioselective reaction mechanisms, including the simple diastereoselectivity, chiral auxiliaries, enantioselective catalytic oxidation and reduction that feature in the advanced stages of all UK university degree courses to aid undergraduate students’ understanding of this key aspect of synthetic organic chemistry.

Results

We have created a collection of animated important stereo- and enantioselective reaction mechanisms (using Spartan 08 <www.wavefun.com/> and Firefly <classic.chem.msu.su/gran/gamess/index.html> and embedded them into ChemTube3D <www.chemtube3d.com/>. We used a combination of Jmol’s button driven interface and our own intuitive image map driven point and click approach to present the reaction schemes and key transition states. This approach of web-based delivery is particularly relevant to the study of chemistry. It allows for various styles of display, interactive rotation, magnification, and measurement. It can be used for lecture demonstration or for private study on any PC anytime, anywhere. Spartan also allows the calculation of various molecular properties including orbitals that can be displayed graphically and can be used to explain aspects of reactivity.

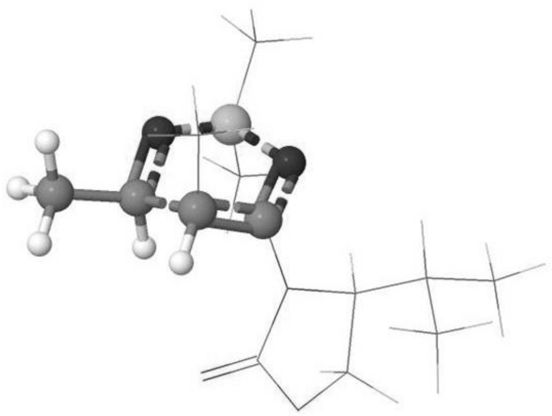

Figure 1: Chair transition state for enantioselective aldol reaction controlled by Evans auxiliary

Web-based Interactive 3D Simulations

We believe that this is a world-leading collection of animated simulations that is revolutionising the teaching of organic reaction mechanisms.

We have covered many of the important stereo- and enantioselective reaction mechanisms to be found in the final years of a typical UK undergraduate course, including the simple diastereoselectivity (Aldol – Z vs E enolate, kinetic vs thermodynamic, chiral aldehydes), chiral auxiliaries (e.g. menthol, 8-phenyl menthol, hydrazines (Enders), amino alcohols (Meyers), chiral carboxylic acids (Schollkopf), oxazolidinones (Evans), sultams (Oppolzer), sulfoxides and enantioselective catalytic oxidation (Sharpless Epoxidation).

Our proven computational approach was to locate the transition state of the desired reaction, and then use the Intrinsic Reaction Coordinate feature to create the reaction path, which can be exported to Jmol. Typical reaction sequences include unbonded - partial bond – single bond and double bond – single + partial bond (aromatic) – single bond and these were crucial for the visual impact of the animations as they emphasise where the changes are taking place and on the progressive changes in bonding as the reaction proceeds. Using features of Jmol, we have incorporated atomic charges, lone pairs and 3D curly arrows into all the mechanisms. We used the familiar ChemDraw 2D representation of the reaction mechanism using curly arrows to control the 3D Jmol display.

The webpages pages were produced through the work of undergraduates whose recent experience of the material ensured the interactive controls highlighted the most important aspects of the reactions.

Dissemination

The animated reaction sequences files, the tutorial web site that uses these animated sequences to display interactive reaction mechanisms, and guides to creating further similar material using Spartan/Firefly/Jmol are available for reuse via the <www.chemtube3d.com> web site.

ChemTube3D is part of the Skills for Scientists OER project so the reactions can be used by UK academia as presented or the animated structure files (standard .xyz format) may be redeployed in customised Jmol based pages or elsewhere as required under the Creative Commons licence.

Outputs

At present there are well over 100 different animated reaction sequences in ChemTube3D <www.chemtube3d.com> ranging from simple nucleophilic substitions (S_N2) to Diels-Alder reactions, palladium(0) catalytic cycles, aromatic heterocyclic reactions, fragmentations and 30 pages devoted to atomic and molecular orbitals, electrostatic surfaces and vibrations.

We have taken advantage of Google webmaster tools to create and submit sitemaps to major search engines at regular intervals. This ensures maximum visibility of all pages to interested parties and is particularly important for a resource such as this that does not need to be entered via the home page. Google Analytics was enabled on all pages to monitor usage over the lifetime of the project and this provided fascinating insight into usage patterns. There have been over 222,000 unique visits from 180 countries spending on average 2 min 10 sec and consulting ~2.5 pages. In May 2011 we have seen over 1000 visits per day. The website is now widely used in the teaching of Chemistry in Liverpool and elsewhere in the world. Major UK users include Oxford, Cambridge, Bristol, and the US is led by Illinois, UCLA, Texas, Harvard, Cornell and Columbia.

Conclusion

ChemTube3D has been a spectacular success and represents an important resource for student-centred and active learning in organic chemistry, whilst providing an example of the general power of animations and simulations in teaching. We believe that this is a world-leading collection of animated simulations that is revolutionising the teaching of organic reaction mechanisms.

ChemTube3D was developed at the University of Liverpool by Nick Greeves, Neil Berry, Alex Lawrenson, Kirsty Barnes, Lyndsey Vernon, Sze-Kie Ho, Suzanna Hussain, Smaher Butt, Richard Windsor, Louise Phillips, Hannah Godfrey and Daniel Meadows using Spartan 08, GAMESS, PC-GAMESS/Firefly, MacMolPlt and visualised using Jmol.

Department Project Report

What's the Problem with Problem-Solving?

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What's the Problem with Problem-Solving?

Problem solving is an important component of every physical science degree: as well as equipping our students with knowledge of whatever domain they are studying, it is essential that our degrees provide them with a 'tool kit' of techniques with which to approach problems. True problems (as opposed to exercises) are those where the solution path is not immediately apparent at the outset, but instead must be deduced as part of the solution process, i.e. our students have to "know what to do when they don't know what to do". The development of problem solving skills is a key attribute both for those graduates intending to remain within their specialism, and also for those entering a career in the wider field: problem solving skills are consistently rated by graduate employers as one of the most valued and desirable skills in physical science graduates[1,2].

Despite its clear importance, problem solving skills development often falls squarely into the region of the learning environment that has been termed 'the implicit curriculum': the set of values, attitudes and attributes that we frequently *assume* our students will naturally acquire during their time as undergraduates, often with insufficient explicit teaching. Not only do we expect students to obtain these skills from somewhere in the ether, our curricula and assessment practices can sometimes actively detract from their enhancement. Syllabi that are stuffed full of content afford little time for reflective and deliberate practice; assessments that take the easy-to-set-easy-to-mark approach often involve short-term memorisation of large volumes of material, and application of familiar techniques to solve exercises masquerading as problems.

In this project, we set out to examine some specific aspects of the very broad topic of problem solving skills acquisition, falling under these themes:

- Uncovering how effective problem solving skills are acquired inside and outside the classroom, and
- Evaluating the effectiveness of specific instructional measures to improve problem solving skills.

Within theme 1, the first topic we considered was the development and evolution of students' informal study networks. While they are present in the classroom, we can have a reasonable amount of control over and a good understanding of what activities students are conducting. However, we know that a very large proportion of student learning occurs in their own time: in particular, much of the practice of problem solving occurs when students work on problem assignments. Students are encouraged (and do) work collaboratively to reap the benefits of peer learning: however, we know very little about how, when and where this informal group study occurs. Employing a technique developed by Brewe and colleagues[3], we surveyed physics students in all years of the programme at three points throughout the academic year, asking them who they had studied with in the previous fortnight. From this data we were able to generate network maps of the interaction between the students. The resulting networks are complicated and will be the subject of much future study. However, some outcomes are very clear: there is essentially no meaningful interaction whatsoever between different years of the programme (and so students are missing out on both the 'trickle down' of expertise from their older peers and on the opportunity of consolidating their own skills while imparting knowledge to their younger peers); and a surprising proportion of the first year students are conducting significant study of physics with other students who are not registered on the physics programme at all.

We have also conducted a high-time-resolution study of the acquisition of problem solving skills in Newtonian mechanics over the duration of our first year course. Diagnostic testing using the pre- and post-instruction testing scheme is a well established technique for determining the level of student skill acquisition over the course of a period of instruction; however, it does not tell us exactly when those skills are acquired relative to their specific point of instruction. We have adopted the approach of Heckler and Sayre[4], wherein different small (equi-able) groups of students are given the same diagnostic assessment in each week of the course. The assessment instrument consists of multiple elements drawn from all topics in the course: thus, the point of acquisition of each topic can be investigated. Again, the results of this study are complicated. However, it is very clear that a simple model of 'learning follows instruction' does not apply: just because a topic has been 'covered' does not mean that it is safe to assume that it has been satisfactorily acquired by the class in the following weeks. Furthermore, high-level acquisition of skills appears to require extended, deliberate practice: enhancement of student skills in a particular area appears to be strongly promoted by employing the skill repeatedly in authentic contexts over an extended period of time.

What's the Problem with Problem-Solving?

The development of problem solving skills is a key attribute both for those graduates intending to remain within their specialism, and also for those entering a career in the wider field...

For several years, one of the principal objectives of the weekly coursework assignment in our first year physics course has been to promote problem solving strategies. However, characteristically the students tend to focus their main efforts on obtaining the final answer, without properly explaining the physical principles in use or the process needed to arrive at the answer. This goal focus diverts attention away from the strategies used to arrive at that goal, to the detriment of their identification and development by the students. In order to clearly highlight the intended purpose of the weekly assignments, we adopted a rubric-based assessment scheme. A rubric is a multidimensional assessment grid, where a number of characteristics of the work are each individually assessed according to their own quality criteria. Our assessment rubric was adapted from one introduced by Docktor and Heller[5], and featured criteria for Strategic Approach, Physics Explanation, Mathematical Execution, and Final Answers. Since the final goal constitutes only one of the four assessed characteristics – and thus can attract only 25% of the available marks – it was much clearer to the students which aspects of their answers required more emphasis to improve the overall quality of their submissions. The rubric appears to have been successful in this regard: over the course of the semester, mean student scores in all criteria rose, but by far the largest relative increase was for Physics Explanation – typically the weakest aspect of the previous years' assignments. In addition, the rubric was popular with the students: when surveyed, they scored it much more highly on questions about assessment akin to those on the National Student Survey than is usually the case for our graduating students.

The final thread examined in this project was that of student-generated content. *PeerWise*[6] is a free, online system developed by Denny and colleagues at the University of Auckland: *PeerWise* allows students to author, share, answer, rate and discuss multiple choice questions, using a straightforward and easy-to-use Web2.0-style interface. We deployed *PeerWise* in our first year physics class and set an assignment task requiring participation in the system. As a result we saw greater engagement with out-of-class study activities, an enhanced sense of community in the class, and evidence of positive correlations between use of the system and improved performance on the final course assessment. The most striking and unexpected observation was that of the quality of the submitted questions: there were very few frivolous, trivial or unchallenging submissions, and the general standard of question was extremely high. At the upper end, the best questions were of simply outstanding quality, featuring interesting contexts and requiring engagement with sophisticated physics over a multi-step solution process, i.e. 'true' problems of the most desirable kind. *PeerWise* seemed to unleash a rich vein of creativity in our students on which we had previously failed to capitalise, and in doing so added a useful extra dimension to the course.

Summary

The successful acquisition of strong problem solving skills is a key requirement for our students. We have seen that it is possible to probe when and where these developments can take place: the picture is a complicated one, and simple 'transmission' models of learning clearly do not apply, but some important features are clearly apparent, and responses can be formulated: for example, we are introducing a coordinated peer tutoring scheme to try to break down some of the observed inter-year barriers. Some relatively simple interventions (rubric-based assessment and student generated content tasks) have been seen to help promote problem solving skills acquisition and also to enhance other aspects of the community of learning.

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The Use of Personal Response Systems

Department Project Report

The Use of Personal Response Systems (PRS) Across the Chemistry Curriculum

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Introduction

The Department of Pure and Applied Chemistry at the University of Strathclyde had become increasingly aware of the need to continue to expand and improve our teaching / delivery mechanisms to ensure that the needs of our diverse student population were met. Although a wide range of teaching tools (lectures, videos, animations, peer-learning) was already in use it was recognised that a better system of rapid response was required to ensure continual formative feedback during teaching semesters. The use of Personal Response Systems (PRS) is the perfect vehicle to achieve this.

PRS were used in a proof of concept study in one lecture course in 2009. The benefits were immediately obvious. Students who were having difficulty with the material were highlighted and offered support and an increased pass rate was observed. The PRS trial was clearly a success, but the time required to implement the system into the lecture course was significant. Discussions with academic staff indicated that there were concerns regarding the time which would be required to incorporate PRS into teaching and the ease with which the software could be mastered. It was recognised that without a dedicated member of staff to implement the use of PRS in Chemistry teaching it was unlikely that the practice would be rolled out effectively.

Also in 2009, our Department appointed four Teaching Associates (TAs) to support second year student learning in the areas of organic, inorganic, physical and analytical chemistry. The methods used to identify students with difficulties have varied: previous year's performance, homework exercises, quizzes on the VLE, etc. However the main disadvantage of such approaches has been the time delay from identification of student need to implementation of student support. Often students are identified as struggling only when failing an examination at the end of the semester.

Project Outline

The funding provided by the Higher Education Academy allowed the appointment of two Research Associates (RAs) for a six month period. Both RAs would rapidly roll out the use of PRS across Chemistry in the time available. Their key tasks were to familiarise themselves with the software associated with the PRS and demonstrate its use to both students and staff. They were then to assist academic staff to incorporate this software into their class material and develop questions which students would respond to during lectures and tutorials.

Lecturers would then have the ability to immediately identify concepts students were not engaging with and could tailor their teaching to address this. Individual students with deeper understanding difficulties would be rapidly identified and directed towards the support network which already exists in the Department through the TAs.

Outcomes

The outcomes of this project will be:

- Expansion of delivery/teaching methods.
- Improved teaching as a result of rapid formative feedback to lecturers, tutors and TAs.
- Increased engagement with students by using novel electronic systems to challenge learning outcomes.
- Increased understanding and reflection on material for students.

And will lead to:

- Improved pass rates.
- Improved student retention.
- More effective graduates with the knowledge and skills required to compete in the industrial and academic sectors.

Often students are identified as struggling only when failing an examination at the end of the semester.

The Use of Personal Response Systems

Project Results

Engagement with Students

The RAs wished to establish if students were comfortable with the use of PRS to assist in their learning. A quiz session was arranged and the results were analysed. Students indicated that they believed the introduction of PRS would be useful/very useful as follows:

Lectures	55%
Tutorials	75%
Class tests	54%

They were also asked to indicate how useful/very useful their introduction would be in specific Chemistry areas:

Forensic and Analytical Chemistry	51%
Inorganic Chemistry	42%
Organic Chemistry	62%
Physical Chemistry	42%

60% of students agreed that the use of PRS would definitely aid or aid to some extent their concentration in class.

Engagement with Staff

Immediately after their appointment, the two RAs familiarized themselves with the software for the PRS (this can be downloaded from <www.einstruction.com/support/downloads> and installed it on all departmental laptops so that it is now easily accessible to staff.

Each RA was assigned a number of academic staff with whom they engaged. Staff teaching in semester 2 of the 2010/2011 academic year were targeted initially so that the use of PRS could be incorporated as quickly as possible. This would allow outcomes to be rapidly identified. The RAs then engaged with colleagues who will teach in the first semester of the 2011/2012 academic year.

The benefits were immediately obvious. Students who were having difficulty with the material were highlighted and offered support and an increased pass rate was observed.

Conclusions

The aim of this project was to embed the use of PRS across the second year Chemistry curriculum and this was successfully achieved. This allowed TAs to fully engage with students who required support in specific subject areas. It also had the added benefit of clearly highlighting those students who refused to accept the support offered. This enabled the Department to come to very clear decisions regarding the progression of this class of students on their respective courses.

While it is not possible to assess fully the results of this introduction (because the teaching for October-December 2011 has yet to take place), an early assessment can be made based on the results of the May 2011 examination results for our second semester teaching. The pass rates in Organic Chemistry (2010 75%, 2011 84%) and Medicinal Chemistry (2010 51%, 2011 82%) showed clear improvement. There was no change to the pass rate in Physical Chemistry (76%) but the mean mark improved, indicating that the level of student understanding had improved. There was a slight decrease in the pass rate for Analytical Chemistry (2010 97%, 2011 95%) but as the figure remains high this did not give cause for concern. The 2011/12 academic year will see full implementation of the use of PRS throughout second year. Analysis of the pass rates and average marks for classes at the end of the 2011/2012 academic year will provide useful information regarding the success of the PRS introduction. We will also study retention figures at this stage and see the effect which has been made on them.

We gratefully acknowledge the support form the Higher Education Academy UK Physical Sciences Centre. ■

It also had the added benefit of clearly highlighting those students who refused to accept the support offered.

Screencasts and Vignettes

Department Project Report

Screencasts and Vignettes: flexible teaching aids for undergraduate chemistry

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Dr Simon Lancaster at the University of East Anglia had experimented with the use of first audio and later screencast recordings of parts of first and second year inorganic chemistry courses. The recordings were well received by the students and prompted their author to present his experiences at the 2010 Variety in Chemistry Education meeting in Loughborough 2010. It's easy for individual academics to feel isolated but it was apparent at Variety that there were many such screencasting projects taking place in chemistry departments across the country, particularly Dr David Read and Charles Harrison at the University of Southampton. Drs Read and Lancaster agreed a collaborative proposal to the UK Physical Sciences Centre to gauge the impact of a more concerted programme of screencasting. The objective of both Schools was to provide access to more than 50% of their first year chemistry lectures.

It's easy for individual academics to feel isolated but it was apparent... that there were many such screencasting projects taking place in chemistry departments...

It quickly became evident that conclusions about the effectiveness of screencast archives were likely to be relevant across the physical sciences community. However, the authors doubted that individual screencasts of whole lectures would be welcomed by other institutions. In keeping with the UK Physical Sciences Centre's ideal of producing resources that would be of value to the whole community they struck upon the use of Vignettes, where the term 'vignette' refers to a short segment of a screencast covering a critical concept.

At UEA, the screencasts were recorded during undergraduate lectures by experienced faculty and edited under direction by postgraduate students. The resulting, typically five minute, vignettes were annotated to introduce highly visual aids and emphasis evolving in real time with the voice of the lecturer. The Camtasia software package employed also allowed the embedding of interactive question elements probing the understanding (and the attention) of the user. Therefore, while screencasts are essentially video files, and vignettes can be provided in such a format, in order to retain the interactivity they must be distributed as SCORM (Sharable Content Object Reference Model) folders. SCORM elements are designed to interact with a learning management system. At UEA they are used within Blackboard and installation is straightforward.

From the outset the Vignettes have been created with open access in mind and are available with creative commons licenses to the entire academic community. To facilitate access, a dedicated website www.chemistryvignettes.net has been established, where the chemistry vignettes can be evaluated and the SCORM packages downloaded. To further encourage institution independent dissemination the project can be contacted by email at chemistryvignette@gmail.com and on Twitter @ChemVignette. The concept and potential of the Vignette is one that needs to be experienced to fully appreciate and readers are strongly encouraged to visit the website and to access one of the Vignettes. The resources will also be made available from Jorum.

From the outset the Vignettes have been created with open access in mind and are available with creative commons licenses to the entire academic community.

Screencasts were made available as quickly as possible... statistics suggest that students tended to access them primarily at the time of associated assessments.

Screencasts and Vignettes

Screencasts were made available as quickly as possible after the lectures, but access statistics suggest that students tended to access them primarily at the time of associated assessments. As has been found in earlier studies, students are strongly in favour of the provision of screencasts. Of the UEA first year chemistry cohort, which had access to over fifty screencasts by the beginning of the examination period, 92.5% said that they found the screencasts either useful or very useful, with 52.5% of the students watching more than half of the available archive. The focus group remark "Needs a screencast for all lectures - sometimes some can be missed out, and means may forget to revise that section" was both a pleasing indictment of the screencast and a warning of how quickly students can take resources for granted and come to depend upon them.

...both a pleasing indictment of the screencast and a warning of how quickly students can take resources for granted and come to depend upon them.

As a result of the greater production time and the novelty to the student of the Vignette resources it was decided to release these en masse to students over the Easter vacation and in the run-up to the UEA examinations. The collection was live between the end of April 2011 and the last examination on 8th June. The Blackboard statistics revealed more than 400 hits on several of the Vignettes, suggesting approximately three accesses for each of the registered students. A more detailed analysis revealed some students accessing the vignettes many more than three times, while other students did not engage with the resource.

Students' perceptions of the vignettes were evaluated through both an online survey and independently facilitated focus groups. The vignettes scored less highly than screencasts with 70% stating that they found them either useful or very useful. The focus group revealed that the reasons for this were largely technical and resulted from compatibility of the SCORM format with personal computer and browser configurations. In the focus group one student commented "Vignettes definitely helpful, condensed a lot of work into a small time - but more as a recap than learning".

So while the initial evaluation is encouraging the real test for the Vignette concept will come during the next academic year, when the student have access to a full set of resources throughout the year and can familiarise themselves with the technology in advance of the examination period. It will also be possible to ascertain how vignette resources exchanged between UEA and Southampton are received by the students.

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■

... one student commented "Vignettes definitely helpful, condensed a lot of work into a small time..."

ChemPreLab

Department Project Report

ChemPreLab: chemistry pre-lab virtual experiments

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Introduction
Practical skills are a fundamental part of undergraduate courses in science, especially in chemistry education. They play a crucial role in enhancing the student learning experience, increasing motivation and enjoyment of learning. Hands-on experiments introduce new apparatus to the students, train them in practical skills and safety issues, and improve their data interpretation skills. Consequently, the students will be able to understand and apply scientific concepts for the duration of their degree and beyond. Practical laboratories need to be carefully planned to increase students' knowledge, time management and problem solving skills, reporting, and data analysis.

Hands-on experiments introduce new apparatus to the students, train them in practical skills and safety issues, and improve their data interpretation skills.

We proposed to provide additional innovative support for chemistry students to improve chemistry laboratory courses. There were not any pre-lab activities available for chemistry students to help them to prepare themselves before their practical sessions start and the students were not getting the full benefit of the learning opportunity on offer through our practical courses. We proposed that this would be tackled through the provision of pre-lab tutoring system via our virtual learning environment (VITAL). Thus when the students are in the laboratory they are more familiar with the experiment they are undertaking both from the practical (e.g. familiarity with equipment) and theoretical (e.g. mechanisms or equations) point of view.

Similar pre-lab systems in other universities have demonstrated the effectiveness of interactive chemistry lab simulations to enhance students' learning. The highly interactive contents make operations of laboratory instruments and experimental procedures more comprehensible and students can better understand the logical relationship between experiments and theories which they have been taught. The laboratory becomes a safer environment for learning, and expensive chemicals are less likely to be wasted.

Introductory Chemistry procedures
Model ChemLab Pro which was originated from academic work in computer simulation and software design at McMaster University has been subsequently extended for the application of computer simulations for online learning. It provides both an animated simulation and a lab notebook workspace including separate areas of theory, procedures and student observations. The software is provided with the commonly used lab equipment and glassware e.g. hotplate, magnetic stirrer, balances, distillation equipment and conductivity meter. ChemLab offers a range of pre-designed common lab experiments such as titration, heating and physical properties measurements. Therefore, we include these pre-designed experiments using Model ChemLab in VITAL as part of an introductory chemistry lab procedures.

Pre-lab tutoring system
After considering all the options for pre-lab tutoring system, we decided to prepare video clips and photos of the key skills used in the experiments with details of the equipment and experimental procedures to help our undergraduate chemistry students with their practical courses. These videos and photos will be available for students to use in conjunction with their online assessments. The first year students can use the introductory virtual experiments produced using ChemLab to learn about

The highly interactive contents make operations of laboratory instruments and experimental procedures more comprehensible...

ChemPreLab

The online assessment is designed to examine the students' comprehension of the underlying theories and their lab knowledge.

the basics of these methods. The video clips and photos will then be available for the students to gain a full explanation of the techniques and equipment used during the lab course. The pre-lab tutoring system is used to help students to understand the theoretical concepts and build their self-confidence to perform lab activity in their practical sessions.

The online assessment is designed to examine the students' comprehension of the underlying theories and their lab knowledge. The assessment for each experiment is a balance of different types of questions including multiple choices, true/false, fill in the blank and short answer. A bank of questions has been prepared for each experiment for the online assessments; these include questions related to the background, experimental procedure and treatment of results. Students can have one or more attempt to answer the questions depending on the experiment. Students get immediate feedback after answering the questions and the assessments are marked and saved in VITAL automatically. The tutors will be able to check the results and if the student fails the online assessment they will be asked some more questions before starting the practical experiment to ensure they have reflected on the given feedback. Each student must pass the pre-assessment test to the satisfactory level before starting the experimental work.

Evaluating of the pre-lab tutoring system

We released the online assessments to the first year undergraduate students over the last week of organic and physical chemistry practical courses; in order to trial them in conjunction with the relevant lab modules. The pre-lab assessments should be completed before the students attend the practical session. The assessment for the students of the organic course was compulsory, whereas the online test for the students of physical chemistry course was not enforced. However, the students of physical chemistry course were advised to take the online test. The results of online assessments for the two lab courses indicated that not many students would use the pre-lab activities and take the online test if it is not compulsory. Also, the students who took the test performed better in the lab comparing to their performance in the previous sessions.

Future plan

We plan to complete the pre-lab online assessments for the first and second year undergraduate labs by the next academic year. The students' marks for completion the online test will be credited to their final mark of the module. Photos and videos focusing on the key techniques used in all the lab courses will be produced and integrated into VITAL. These may either be as standalone files or incorporated into a learning aid. Proper evaluation of the pre-lab activities will be held in the next academic year, when the students have used this system for the whole period of their practical courses. We will send an evaluation form to the students to complete at the end of the lab modules.

Summary

The progress on this project has been satisfactory. The module leaders of the courses are happy with the pre-lab tutoring system and they are already positive that the system is beneficial to our students. Our undergraduate students have always complained about the lack of information and clarity of some experiments in the lab courses. Reviewing all the students' questionnaires from the past, we have focused on rectifying the weaknesses of our current lab courses using the pre-lab tutoring system. ■

The module leaders of the courses are happy with the pre-lab tutoring system and they are already positive that the system is beneficial to our students

Imagine you are a lecturer for a day

Imagine you are a lecturer for a day. How would you teach your students?

UK Physical Sciences Student Award 2011

This year the entries could be in any format the student chose.

Here is the winning entry for 2011 to the UK Physical Sciences Student Award competition by...

Paul Brack

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If I were a Physical Sciences lecturer, how would I teach my students?

Bear with me, if you will, while I tell you a story.

A young man went to study a scientific course at a University. On his first day there, he was talking with one of his fellow students. She had attended a good school and obtained respectable A-level results. The subject of discussion turned to motivation; why did you come to university? His answer was clear – to enter the profession he desired to, a degree was necessary. Not only that, the subject excited and inspired him. Her response was less clear. She was mainly there to avoid having to look for a job for another few years, to have some fun. The subject interested her, but she lacked passion. She was not nearly as deeply engaged in the course as he was. It was for her, something to do, but little more.

He sparkled and achieved a first class degree. She did not. She held on and completed the course, but never seriously contemplated a job in the field of her study. She was still not excited by it.

During my time as a Chemistry undergraduate I have met people like him and people like her, from all sorts of backgrounds. For me it is sad that I have met more of the latter.

Why am I telling this story? I tell it because it highlights the major problem facing a lecturer in the Physical Sciences, that of student disengagement. If students are engaged, they learn, they study, they are enthusiastic and passionate, and most importantly, they succeed. If students are disengaged, they struggle, they avoid lectures and they do not realise their full potential.

So, if student disengagement is the problem, how would I as a lecturer address it?

It's difficult to give a single answer to that question. There is, as far as I can tell, no magic cure for apathy. Different approaches will engage different students. There are, however, some overriding principles that I would apply.

Firstly, I would be interested. Not just in the student, but as importantly, in my subject. I would demonstrate through my body language, my words and my teaching materials that I found what I was sharing to be absolutely fascinating. I would tell them how useful it was, how it had invaluable applications in a variety of settings, how it was truly important and of real worth to society.

On occasion I have heard lecturers making statements such as 'this isn't very exciting but we have to cover it.' More often I have seen lecturers betraying by their demeanour that there and then frankly the last place they wanted to be was giving a lecture to undergraduates. This negativity is noted by the students, and gives many of them a similar feeling.

Happily, I have also been in many a lecture where the academic clearly feels that what they are about to share is exciting and useful, and such contagious enthusiasm is caught by the listeners. These become the lectures where attendance is high and people want to be there out of engagement and this is how I would aim to teach.

Next, I would demand scholarship. This would doubtless be painful for many students, habituated as they have become to the 'spoon feeding' of A-level teaching, where they do not have to learn the art of scholarship in order to succeed. Thus undergraduates come with the expectation that all they need to know will be supplied by the lecturer. Too often current teaching practices reinforce this assumption, as tutorials and examinations can indeed frequently be passed with high percentages largely by memorisation and repetition of lecture notes.

If students are engaged, they learn, they study, they are enthusiastic and passionate, and most importantly, they succeed.

Imagine you are a lecturer for a day

..I have also been in many a lecture where the academic clearly feels that what they are about to share is exciting and useful, and such contagious enthusiasm is caught by the listeners.

How to counter this? A paper discussing lectures in Physics states that "lectures can be incredibly passive experiences for students, particularly dangerous for those who believe that if they follow the professor, they've mastered the material[1]". Thus I would endeavour to make my lecturers interactive. Technology which allows audience members to vote using a keypad has already been successfully used in lecture theatres. I would make this a regular occurrence in mine, to help the students to think about the topic of the lecture, and, as they inevitably get some questions wrong, to realise their need of scholarship to gain a true comprehension of the subject matter.

To develop scholarship outside of lectures I would hold assessed problem sessions where the answers could not be found simply by looking at my lecture notes or by a cursory glance at a textbook. The students would have to develop with their own answers through thinking and studying. I would also incorporate this to a point in my examination papers. This would make students far better equipped to succeed in the world of work.

Finally, I would tap into the power of my students by empowering them to help each other. The University of Manchester currently has 18 Peer Assisted Study Session programmes across 4 faculties[2], where higher year undergraduates voluntarily act as learning facilitators for their fellow students. The beauty of the scheme is that, by shifting some of the tutoring burden from themselves onto engaged and enthused PASS leaders, lecturers can simultaneously help their students to learn and have more time to focus on their own research, which is of such importance to the respective department and university. Student leaders are developed all whilst developing and inspiring their fellows to a greater commitment to and understanding of their discipline of study. Other universities have already begun to follow this model[3], and if I were a lecturer, I would endeavour to establish it as soon as possible in my department, as it's ability to aid achievement is immense.

To summarise, the main challenge facing a lecturer of the Physical Sciences is that of student disengagement. If I were a lecturer, I would counter this by demonstrating clearly my passion for the subject, by helping students to develop the skill of scholarship, and by empowering my students to facilitate one another's learning. These three approaches are interlinked and aim at the root of the problem. They would motivate and inspire students to excellence and deliver to the job market trained and competent scientists, filled with passion for their discipline and ready to make the breakthroughs our world so desperately needs.

References

1. Van Heuvelen, Am J Phys 59 (10),1991,891-897
2. <www.campus.manchester.ac.uk/tlso/studentsaspartners/peersupport/pass/schemes/>
3. For example, Loughborough University ran a pilot scheme in the Department of Chemistry in 2009.

Student leaders are developed all whilst developing and inspiring their fellows to a greater commitment to and understanding of their discipline of study.

Farewell (or 'Roger and Out')

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Roger Gladwin, our Communications Manager, retired at the end of 2010. Roger has been a valued member of the Subject Centre team since it started as part of the LTSN in 2000. Roger had a long career in the support of learning and teaching and is well known and respected across the disciplines.

Roger joined the CTI Centre for Chemistry as Manager in 1989 after spells in the pharmaceutical industry and Hewlett-Packard. Space constraints within the University meant that Roger had to share an office with the CTI Centre for Biology. This proved serendipitous as Roger formed a close relationship with his Biology counterpart and this led to a fruitful cross-fertilisation of ideas.

One of Roger's initial tasks was to produce the first UK catalogue of software for Chemistry teaching. This involved a detailed survey of all published material and it revealed a surprisingly large number (in excess of 300) of programs. It soon became apparent that a large proportion of these were of poor quality and, since most originated in the USA, were not well suited to the UK environment. Accordingly Roger determined that future editions of the catalogue should only contain entries for which peer reviews existed. It turned out that that there were very few such reviews as conventional journals were not equipped to deal with non-print material. The bold step of publishing our own journal was Roger's solution to the problem and "Software Reviews" was born. This appeared every 6 months and eventually received sponsorship from the Chemical Industry. Ultimately, this publication evolved into our own *Reviews* journal.

Roger spent much time speaking to academics around the country both at formal meetings and informally. He generated an enthusiasm for computer-based learning that could not be satisfied with the then-available published material and it was suggested that the CTI centre should consider writing its own software.

Roger undertook to canvas the whole chemistry community in support of a 'Chemistry Courseware Consortium' drawn from academics across the UK. The Committee of Heads of University Chemistry Departments, the Royal Society of Chemistry and the Chemical Industries Association gave the project their overwhelming support. In addition the Open University made a substantial commitment of resource by allowing the use of their software tools for the graphical presentation of scientific concepts and to provide training in their procedures. Roger made it clear that the writing of commercial quality software is very time consuming and used his knowledge of 'industry standard' figures for personnel efficiency and input/output ratios to produce a document that became the framework for the national Teaching and Learning Technology Programme. Needless to say, when the Programme was announced, the Chemistry CTI bid was successful and Roger became the manager. The software eventually became self-financing and a second edition was published several years later.

In 1998 The CTI Centre was designated by UNESCO as a 'Centre of Excellence' for the use of IT in the teaching of chemistry and physical science. In no small part due to the tireless work of Roger.
After nearly twelve years of championing the cause of computer based learning, the Centre was incorporated into the LTSN as part of the wider support for university students and academics. Roger became an integral part of the new centre.
Roger's major responsibilities in the new LTSN Centre included organising Open Road events, which took software and other resources around the UK. He also designed and maintained our first website and designed and produced all our publications. Those of you who remember those garish yellow publications and website can testify to how Roger's skill at design has evolved over the years. The very professional look and feel of all our publications is down to Roger. He can also be credited with the design and usability of our website which has been such a useful resource over the years.

Since he left the Centre we have undoubtedly missed his professionalism, expertise and good sense. But we have also missed his good humour and team spirit. And we've also missed sharing a pint or two! We wish him well for a long and happy retirement. ■

Discipline Support beyond July 2011

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Many of you will by now be aware that the UK Physical Sciences Centre will close on 31st July 2011.

The Higher Education Academy has restructured and has decided that all discipline-focussed support will be provided by staff based at their headquarters in York. Support for the physical sciences will be lead by the new STEM lead, Janet de Wilde. Janet will join the Academy from the University of Edinburgh where she is currently the Executive Manager of SINAPSE, a neuro imaging research network. She previously managed a researcher development programme at Heriot Watt University.

...the Academy's work will now be focussed around... Academic Practice Development, Teacher Excellence and Institutional Strategy and Change.

The new physical science lead is Paul Yates. Paul will already be known to many of you, especially chemists, as he has a long standing interest in chemistry education. He currently works in the Centre for Professional Staff Development at Keele University but was previously a physical chemist in the same institution. He has published several textbooks and articles on maths for chemists.

All of the Academy's work will now be focussed around three themes. These are Academic Practice Development, Teacher Excellence and Institutional Strategy and Change.

The Academy website carries the following statement:
Support at subject level to academics in their discipline communities will remain at the heart of our work. From 2012, this support will be delivered through subject specialists directly employed by or seconded to the HEA. Flexible employment arrangements mean that many academic staff and associates will be based in HEIs throughout the UK.

Support for the disciplines will include the following activities:

- Funding for small grants to support teaching, educational development projects and to stimulate innovation
- Workshops and events at subject and discipline level, on key issues in HE identified by subject communities.
- Extension of the Academy's change programmes to departmental and subject level within institutions.
- Development of materials and toolkits for use by academics in their teaching, including for example, e-journals, resource banks, short guides and pedagogic support items
- Support at subject level for initial teacher training for graduate teaching assistants and other new staff
- Subject input into continuing professional development programmes
- Extension of formal links with Professional, Statutory and Regulatory Bodies and subject associations on issues relating to learning and teaching.

Our current website will remain and can be accessed via the Academy's website area for disciplines. However, it will not be maintained. Colleagues might be wise to download copies of useful documents and resources for personal use.
As we wind up our activities here at the Centre, we would like to thank the many colleagues and friends across the UK and beyond who have collaborated with us so enthusiastically. Together we have made a real difference to teaching and learning in the physical sciences.

Best wishes to you all. ■

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New development projects 2011

A new multimedia resource for teaching quantum mechanics concepts by Antje Kohnle, Donatella Cassettari, Tom J Edwards, Alastair D Gillies, Christopher A Hooley, Natalia Korolkova and Bruce Sinclair, University of St Andrews

Crime scene investigator volunteering for forensic science students by Mark Baron, Ruth Croxton, Dorothy Gennard, Jose Gonzalez-Rodriguez, Gillian Fowler and Sara Hobson, University of Lincoln; Dean James, Lincolnshire Police

Development of generic graduate skills addressing problem solving and understanding of fundamental chemistry by Suzanne Fergus, University of Hertfordshire

The use of mobile touch screen devices in teaching crime scene processing to forensic science students by Mark Fowler, Vivien Rolfe, Nigel Scott and Richard Brawn, De Montfort University

Making time for active learning through the use of screencast pre-lectures by David McGravey and Katherine Haxton, Keele University

Dynamic interdisciplinary problem solving in the physical sciences by David Sands and Tina Overton, University of Hull

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The UK Physical Sciences Centre is funded by the Higher Education Academy (www.heacademy.ac.uk) and is part of the Academy's Subject Network. The Centre is supported by the Universities of Hull and Surrey.

Future of the Conferences

Over the past 11 years our flagship events have been the three subject specific conferences which have provided a national focus for those interested in teaching and learning in chemistry, physics and forensic science. Securing the future of these conferences has been a priority for us as we plan for transition to the new HEA.

The forensic science conference, FORREST, will take place at the University of Abertay next June. It will be organised by a group of volunteers which includes representatives of FIRN and UKFSEG, the UK Forensic Science Education Group.

Variety in Chemistry Education has always been the conference of the RSC Tertiary Education Group, and they will take over the practicalities of organising the next meeting for September 2012.

The Physics Higher Education Conference has been supported by the IOP Higher Education Group in the past and we hope that they ensure its future beyond 2011.

Of course, we hope that the new regime at the HEA will recognise the value of these conferences and continue to support them as we have done.

Events
-2011-

- Variety in Chemistry Education Conference, 1st/2nd September 2011, York
- Physics in Higher Education Conference, 8/9th September 2011, Lancaster

Contact us or visit our web site for details.