Celebrating 10 years!

The Centre for Interdisciplinary Science at Leicester is an innovation in University Science Education. In its Natural Sciences programme the Centre offers an alternative approach to undergraduate degrees in Science, both in its pedagogy and in the interdisciplinary nature of the scientific content.

The core content of the programme covers fundamental aspects of Biology, Chemistry, Earth Sciences and Physics presented in an integrated, interdisciplinary context and delivered by research-based learning whereby students engage in the research process throughout their degree. The organisation of the Centre and the pedagogy offer innovative models of learning to the HE sector. The initiative has now been running for ten years; this booklet has been produced to celebrate its success.

The Centre for Interdisciplinary Science was developed initially as part of the Leicester Physics Innovations Centre for Excellence in Learning and Teaching (piCETL) which was launched by the then Chancellor in 2004. The IScience Centre is an outstanding legacy of the CETL initiative.
At the turn of the millennium many of us in higher education were struggling with the need to make science more relevant as a discipline and more popular as a career choice. The number of students taking science subjects was falling, while the opportunities for qualified scientists and engineers were rising.

On the supply side we had developed some experience in Physics at Leicester in the use of problem-based learning (PBL) to contextualise physics concepts. In the PBL approach students learn by researching a problem supported by academic staff. The scope for contextualisation is expanded enormously if one broadens the context to include other disciplines. So was born the idea of a fully interdisciplinary science programme. To make this viable, as well as for educational reasons, we adopted the PBL pedagogy. Having control of the programme also meant we had control of the timetable without the problems of scheduling that bedevil more conventional pick-and-mix approaches.

Once we had course approval, the first action was to gather the heads of teaching in the contributing Departments to an away-day to plan the programme. We all wrote down what we considered to be the topics we thought our students really ought to know at the final year level and worked backwards to fill in the supporting topics. This was a liberating experience; it enables course designers to leave out the material that is simply there by tradition and focus on what is really important today.

This approach addresses what became one of our three key themes: the interdisciplinary scientist. The other two were the student researcher, referring to the PBL pedagogy that requires students to work as researchers throughout their course, not just in their final year project; and the 21st century student, by which we mean the full integration of electronic media in the delivery and assessment of the programme.

In the early years we had to make continual adjustments in response to student feedback. The reason is simple: it is impossible to predict with certainty the student reaction to a new approach; it has to be a question of trial and correction. The programme has been stable for a number of years now and has produced some remarkable outcomes, as I hope these pages will testify.

For its first nine years the programme was supported by external funding from HEFCE and the Institute of Physics through various STEM initiatives. Following an external review in 2012 the University decided to adopt and expand the programme and to change the name of the degree programme (but not the Centre) to the more recognisable Natural Sciences.

Professor Derek Raine, MBE
Associate Director and Course Founder
The 21st Century University:
Evidence based teaching

The nature of the university is changing. Information is now available on demand. The role of the instructor is now to turn information to knowledge. How to do this is the subject of much research and experimentation. But some features of the outcome can be discerned. Central to the avalanche of new ideas will be evidence-based teaching; the key evidence is student engagement.

The Centre is in the forefront of evaluating and enhancing student engagement. The key to gains in student learning is the design of the programme not just of the individual modules. This is why we designed Natural Sciences as an integrated programme with its own pedagogy and content, not as a collection of modules from other programmes. This makes our programme unique.

The contemporary University makes impossible demands on its academic staff, expecting international research, high levels of engagement with teaching, interactions with industry and commerce and with the wider community. In the Centre for Interdisciplinary Science we believe that these outcomes are best delivered by dividing the roles. The major component of teaching is delivered by teaching fellows who hold qualifications in both research and teaching whose principal focus is on teaching and the development of effective teaching. Academic researchers from across the Science Departments contribute individual sessions on their areas of expertise to students who have prepared for the sessions (a mode of delivery now widely referred to as “flipped learning”).

The outcomes of this structure are high quality staff-student interactions, collaborative learning and a sense of community, all of which are known to contribute to student learning gains. This lies at the heart of the research-teaching nexus: our programme delivers not only current research content but also the experience of the research process.

But education is not just about knowledge and its application. As widely recognised, not least through the employability agenda, graduates require a range of professional skills to equip them for the workplace. The pedagogy of research-based learning, whereby our students learn through guided research, enables our students to gain these high level skills in a professional context.

The IT revolution not only alters the context of education but also expands the modes of engagement. New technology has been essential to the delivery of the Natural Sciences programme. It enables us to deliver large quantities of learning materials electronically. Students also submit work and have it marked and returned electronically. We can therefore take advantage of the developments in blended leaning giving us the best combinations of face-to-face delivery and support through electronic media.
Who are we?

Teaching in the Centre is delivered by qualified staff whose main role is teaching and the development of teaching. Meet our staff here.

Dr Paul Howes (Director from 2013)
MA (Cantab), PhD (Leicester) on the use of surface x-ray diffraction to study the atomic structure of interfaces.

Professor Derek Raine MBE:
(Director, 2002-2013, Associate Director) MA, PhD (Cantab) in cosmology. Awarded Bragg Medal 2006 for development of PBL in Physics, first Leicester academic to be awarded a National Teaching Fellowship of the Higher Education Academy 2004, Editor in Chief: New Directions, Hooker distinguished visiting lecturer McMaster University 2010, MBE for services to science education.

Dr Cheryl Hurkett; MPhys, PhD (Leicester) on the astrophysics of Gamma Ray Bursts. Teaching Fellow in Physics and Senior Tutor, Postgraduate Certificate in Academic Practice in Higher Education (PGCAPHE): Fellow of the Higher Education Academy

Dr Sarah Gretton
BSc (Edinburgh) PhD (Glasgow) on the cellular biology of the hepatitis C virus. Biology Teaching Fellow, Head of Pedagogy, Postgraduate Certificate in Academic Practice in Higher Education (PGCAPHE), Fellow of the Higher Education Academy, VISIR Micro-innovator award, 2011 Jorum Learning & Teaching award, University of Leicester Teaching Fellowship (June 2014).

Dr Dylan Williams MChem, PhD (Liverpool) in Nanoscience. Teaching Fellow in Chemistry, Postgraduate Certificate in Academic Practice in Higher Education (PGCAPHE), Fellow of the Higher Education Academy, University of Leicester Teaching Fellowship (June 2012).

Dr Paul Abel
MMath, PhD (Leicester) in Black Hole Thermodynamics, Mathematics Teaching Fellow; University Partnership Teaching Award; Paul also appears on the BBC TV programme The Sky at Night and has contributed to Blue Peter, Newsnight, BBC Stargazing Live, Chelsea Flower Show, BBC 6 Music & BBC Radio Leicester.

Past members of staff:

Dr Sarah Symons (now Assistant Professor at McMaster University) · Dr Tim Barker (now Learning Technology Associate at Keele University)
Dr Sam Atarah (now Research Fellow at LWS) · Dr Emma Tebbs (now Research Fellow at Lancaster University)
Dr Catarina Fernandes (now academic practice lecturer at Nottingham University) · Dr Carys Bennett (now postdoctoral researcher)
Dr Alun Salt, Dr Tania Ruiz, Rebecca Cowling, Sam McCartney, Naomi Banks
Opportunities beyond Leicester

Canadian Exchange Programme

We have been fortunate enough to establish an exchange programme with McMaster University, one of Canada’s leading universities. McMaster is unique in North America in offering a three year integrated science programme which makes it an ideal match for our students. The exchange has been running for three years and a significant number of our students have taken this great opportunity to broaden their experience. For one of our students this has resulted in the award of a prestigious funded PhD position at McMaster.

Additionally students from both institutions collaborate to produce the student journal JIST (more information on Page 7).

“Science for Sustainable Livelihoods” Field Work in Kenya

The Centre leads the University’s Education for Sustainable Development (ESD) teaching initiatives, providing the Sustainable Futures courses for Science undergraduates and coordinating the ESD forum for academic staff. As part of the Natural Sciences ESD programme there is an optional Field course in Kenya: Leicester students engage with the villagers to help produce solutions to some of their problems. 26 Natural Sciences students have been on the course engaging in projects including...

- Improving Rainwater Harvesting Processes
- Management of an Invasive Plant Species
- Assessing Methods of Biochar Production
- Production of Alternative Fuels
- Assessing the Viability of Algae Harvesting as a Food Source

The project gives our students the opportunity to make a real contribution to the well-being of their Kenyan hosts while they develop project skills. This experience has inspired the students to undertake their own fund raising for a local school through the joint development of a sustainability game.
Our Successes

Student Society

The Natural Sciences students have a flourishing student society. As well as social events the society runs a series of seminars given by PhD students in the University about their research, which attract large numbers of students from the Centre and other University departments. The society has also worked with the University’s Careers Service to deliver a Careers Day specifically aimed at Natural Sciences students.

Student Journal

Whilst most undergraduate science programmes provide students with a project, through which they obtain some experience of the process of scientific research, few students get to know the mechanism by which research output reaches the public domain. Fewer still get to appreciate that the hard part of originality in science is to ask the right questions.

Our students learn about scientific publishing and the peer review process by acting as authors, referees, and editors of the undergraduate journal. Split into small research groups, the students come up with original ideas for research, and write short scientific papers. They peer-review the work of other groups in a process overseen by a student editorial board who, based on the referees’ reports of their peers, have the final say on whether or not a paper is published. We encourage the students to be creative in their topic choice and approach but there must be a core of accurate scientific theory that is communicated clearly. The student experience is an accurate reflection of that of professional research scientists.

The 2013-2014 academic volume was the first year that students from our exchange partner, McMaster University in Ontario, were invited to submit papers to the journal as part of their own studies; staff from both institutions agree that it was a resounding success. As far as we are aware this is the first time there has been an international collaboration of this kind as part of an undergraduate degree.

Some of the more creative published papers have gone viral and have been seen on news sites as far and wide as France, Italy, Australia, China and Russia. This year a selection of papers were the subject of several radio interviews (BBC Wales, BBC Warwickshire, ABC Melbourne) and numerous media articles; they even got a mention on the BBC’s Have I Got News for You!

Journal web site:
https://physics.le.ac.uk/jist/index.php/JIST

“...
The quality of the final year projects was astonishing... I can imagine employers being very impressed, several were of a publishable standard.

Student Research Projects

A number of our student projects have led to publications in research journals, including:


- Electrochemical behaviour of brass in chloride solution concentrations found in eccrine fingerprint sweat, Bond J W & Lieu, E, 2014, Applied Surface Science, 313, 455-461


Wider Influence

The Centre has acquired an international reputation for its teaching and curriculum design with visitors coming from across the world to look at our programme and a number of invitations for us to visit. The photograph shows visitors from Arizona State University exploring the Leicester programme. Other visitors include those from New South Wales, Cape Town, Madrid, DCU and consultations by video link with Simon Fraser, (Vancouver, Canada) and Galway IT (Ireland).
From the start the Centre has led pedagogic innovation through externally funded projects. For the first nine years of its existence the Centre was funded largely by external grants. These facilitated the development of the programme. These include support from the CETL grant of £1.25M, HEA NTFS £50K, IOP Stimulating Physics £120K, HEFCE Integrated Sciences £350K. The Centre staff continue to win funding for specific projects from both external and internal sources demonstrating our commitment to continued development and innovation.

External Funding

**Catarina Fernades** – Asteroids Outreach (HEA-STEM, 2012)
**Sarah Gretton** – Sustainability Education (HEA-BioSciences, 2013)
**Cheryl Hurkett** – Teaching Fellows Forum (HEA-STEM, 2012)
**Derek Raine** – Conceptual Understanding in Physics (HEA-STEM, 2011)

**University of Leicester Funding**

**Derek Raine & Sarah Gretton** – Sustainable Futures on line course, Student Engagement (2013), Flipped Learning (2014)


**The Centre as Conference Hosts** – The Centre has hosted a number of international conferences

- GIREP: The major European biennial conference on Physics education was hosted (2010 with around 100 participants from across Europe)
- OQOL2012: The biennial conference Open Questions on the Origin of Life was hosted by the Centre in 2012 (right)
- QI2013: The Centre (jointly with Management Centre) hosted the 2013 meeting of the Quantum Interactions conference
Alumni

As expected from a programme with an interdisciplinary focus our graduates have followed a wide range of career paths. Our graduate destinations include: Post-Graduate Researchers (Geophysics, Computational Evolutionary Biology, Neurophysiology), Science Communicator (National Space Centre), Clinical Research Associate (Icon PLC/Amgen), Search Engine Optimisation Specialist (OMD UK), Finance Manager (Norbert Dentressangle), Regional Sales Manager (DeSoulier Medical), Infrastructure Analyst (Atos), Associate Consultant (JDX Consulting), IT and Technology Risk Senior Associate (KPMG) and Environmental Consultant (Whitecode Design Associates).

[Her] interdisciplinary academic background has prepared her well for the diverse portfolio of work she is engaged with. Furthermore, she has put to good use core business skills developed at university through demonstrating effective communication, problem solving and team working.

Team Leader, Defence Science and Technology Laboratory

What the employers think...

What graduates think...

I work for a multidisciplinary Science and Technology company and the work that I do is varied and can involve subjects and topics that I have never looked at before and have no previous understanding of. The Interdisciplinary Science course helped to prepare me for that by giving me the skills and confidence to approach any topic and to have the ability to bring a number of perspectives to it.

When I was looking for jobs some of the key skills that they were looking for were: leadership, problem solving, communication and being a good team player. The course helped me to develop all of these through their team based problem solving style of learning.

The best thing about the degree is that you can get whatever you want out of it. It provides you with all of the knowledge and skills that you need and the teaching staff are always there to help you develop your own interests that may lie outside of the core modules. I think that I took the opportunity to make the most out of what the course had to offer.
Pedagogic Research and Development

As well as their discipline publications most staff publish their research on pedagogy and teaching developments to disseminate information about the programme that will be of use to educational developers in other institutions and to promote science. Below are some educational publications from the previous 5 years.

Current Projects

Centre staff are currently involved in a number of pedagogic research projects in the Centre and in collaboration.

- Teaching Fellows’ Network (Hurkett) – The Centre hosts a national forum for STEM Teaching Fellows with an annual meeting at the HEA STEM conference
- Student Engagement (Gretton) – A University funded initiative to investigate how students engage with their teachers and peers to get the most out of their programmes
- Sustainable Futures (Gretton & Raine) – This is a project to develop a short private on-line course on sustainable development for students who cannot attend the module workshops.
- The Scientific Process (Hurkett) – This project tracks students’ knowledge of the process of dissemination of scientific knowledge through peer review and publication.
- Students in Groups (Hurkett) – This project at Strathclyde is looking at how students interact in group learning
- Problem Solving (Hurkett) – Collaboration on a project at University of Hull on student approaches to problem solving in programmes with different pedagogies
- Student Attitudes (Raine) – Using an instrument developed by the University of Colorado and employed worldwide we look at how students’ thinking becomes more expert-like across their degree programme
- The IOP Quantum Curriculum project (Raine) – This is a project with the Institute of Physics to develop a web site to support the teaching of modern approaches to quantum physics
- Interdisciplinarity and Research-Based Learning (Raine & Gretton) – This is a project with McMaster University in Canada to study the development of professional skills in an integrated programme.
- Flipped Learning (Gretton & Raine) – Looking at effective ways in which students can prepare for classes
- The development of multimedia resources to facilitate flipped learning experiences (Williams) – A series of short voice-over PowerPoint presentations
- The development of context and problem based learning resources for the chemical sciences (Williams)
- The effectiveness of CBL approaches in widening participation programmes (Williams) – Research into the effectiveness of widening participation projects
- Science communication for undergraduate chemistry students (Williams) – Promoting scientific literacy for chemists

Recent Educational Publications

Dr Paul Abel
- How To Read the Solar System, Paul Abel & Chris North (foreword by Brian May), 2013, BBC Books
- Stargazers Notebook, Paul Abel, 2013, Frances Lincoln Publishing

Dr Cheryl Hurkett
- Supporting the Teaching Fellow Community, C Hurkett & D Raine 2013, New Directions 9 (1), 33
- Visual Images as Hooks for Problem-Based Learning, D Raine & C Hurkett, 2010, GIREP-EPEC & PHEC 2009 International Conference, August 17-21, University of Leicester

Dr Sarah Gretton
- Scaffolding Problem Based Learning with Module Length Problems, 2013, Sarah Gretton, D J Raine & C Bartle, 10th Conference of the European Science Education Research Association, Cyprus

Professor Derek Raine
- Problem-based learning: undergraduate physics by research, Derek Raine & Sarah Symons, 2012, Contemporary Physics 53(1) 39-51
- Scaffolding PBL in For the Love of Learning: Innovations from Outstanding University Teachers (Palgrave Teaching and Learning) Tim Bilham (Editor), 2013, Palgrave Macmillan
- Causality and Complexity in The Causal Universe Ed G Ellis, M Heller & T Pabjan, 2013, Copernicus Centre
- Newtonian Mechanics, 2013, Pantaneto Press
- Black Holes 3rd edition (with E G Thomas), 2014, ICP World Scientific

Dr Dylan Williams
- Context/Problem Based Learning in Chemistry – Sharing Lessons and Making it Work, S Belt et al. 2009, Royal Society of Chemistry
Some Recent Presentations

Centre staff present the results of our educational research and development at national and international meetings. Below is a small selection of presentations from the last five years.

- Interdisciplinary Science, D J Raine and S Gretton, Jasper, 2014
- Undergraduate e-journals HEA STEM Conference, C Hurkett, D Raine & M Roy, Edinburgh, 2014
- A survey of Student Engagement HEA STEM Conference, S Gretton & D Raine, Edinburgh, 2014
- A workshop for Teaching Fellows HEA STEM Conference, S Gretton, D Raine & C Hurkett, Edinburgh, 2014
- Peer-2-Peer: Mentoring for Sandwich Year Chemists, Dylan P. Williams & Sandeep Handa, HEA STEM Conference, Edinburgh, 2014
- Blended Approaches to Teaching Chemistry, Dylan P. Williams, UoL Teaching & Learning Conference, 2014
- The role of scaffolding and the facilitator in PBL, S Gretton, D Raine and C Bartle, Vancouver, 2014.
- Scaffolding PBL across the Sciences, D J Raine, Galway, 2013
- Scaffolding Problem Based Learning , Sarah Gretton, D J Raine & C Bartle, 10th Conference of the European Science Education Research Association Cyprus, 2013
- Causality and Complexity, D J Raine, Krakow University, 2012
- The Emergence of Complexity, D J Raine McMaster University, Canada, 2011
- Teaching Foundation Year Chemists by Problem Based Learning, Dylan P. Williams and Katy J. McKenzie, Variety in Chemistry Education, Loughborough University, 2010
- Developing a Sustainable Approach to Problem-Based Learning in Chemistry, Dylan P. Williams, Eurovariety in Chemistry Education, University of Manchester, 2009

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Advisory Board: Professor Sir Peter Williams, Professor Jack Cohen, Professor Richard Dawkins, Professor Louis Wolpert, Professor Peter Atkins, Professor Sir John Enderby, Sir Crispin Tickell

Steering Group: Dr Maarten Tas, Sheila Brucciani, Dr Ronald McDonald, Professor Tina Overton, Professor Mick Brown, Professor Steve Switchenby, Professor Ken Fogelman, Deirdre Cawthorne, Dr Clive Fox, Professor John Fothergill, Professor Martin Jones and the numerous graduates who assisted in the development of the materials for the programme.
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The Centre runs various free public events. To be included on the mailing list for information please email iscience@le.ac.uk