

The National HE STEM Programme

How the HE STEM Programme led to the creation of new physics degrees

This briefing paper is part of a wider set of analyses for the HE STEM Programme. The HE STEM Programme brought together 6 universities from across England and Wales with the Royal Society of Chemistry (RSC), the Royal Academy and Engineering (RAEng), the Institute of Mathematics and its Applications (IMA), and the Institute of Physics (IOP).

The National HE STEM Programme established a partnership between government, the higher-education sector, funding bodies and other stakeholders to support the provision of science, technology, engineering and mathematics subjects in England and later in Wales. The Programme ran until 2012.

This paper provides background on one strand of the Programme and looks at new degree courses in physics that arose from its work. These new degrees in Applied Physics and Integrated Sciences at three different university departments opened up new opportunities for hundreds of students to study physics. This paper concludes with some brief analysis of the shared experiences and challenges that the development and commencement of these courses have faced.

In partnership with



Background to the HE STEM Programme

The HE STEM Programme was supported by a funding package of more than £20 m delivered via the Higher Education Funding Council for England (HEFCE) and the Higher Education Funding Council for Wales (HEFCW). The hub of the initiative was based at the University of Birmingham, and this was managed in partnership with other universities and professional bodies, including the Institute of Physics (IOP).

Three key aims of the HE STEM Programme were: widening participation in STEM subjects, including reviewing entry criteria and removing any unnecessary obstacles; developing new undergraduate curricula with modern content and a fresh emphasis on relevant skills and career expectations; improving links between universities and employers to design and deliver new content with associated workplace skills.

One major result of the HE STEM Programme was the development of new degree courses pioneered at a handful of universities, their design being informed by the key aims of the HE STEM Programme. This briefing paper comes a sufficient period of time after the end of the programme's funding, with the first cohorts of graduates now having emerged from some of the newly established courses. It reviews three such courses: two new applied physics degrees linked to two, essentially new, departments, and one integrated-science degree linked to a well-established department.

New applied physics courses

University of Portsmouth

Portsmouth has a long and respected tradition of teaching applied physics, going back to the 1950s when it taught the former “external” London degree. Structural and financial changes within the university during the 1990s, however, led to a gradual slimming down of the applied physics department, and eventually to the withdrawal of the degree. Some academic staff departed, while others were redeployed to areas such as environmental sciences, health sciences, or cosmology and astrophysics.

With the advent of the HE STEM Programme, a new opportunity was identified to reintroduce an applied physics degree at the University of Portsmouth; not one that would compete directly with established degrees elsewhere, but one that could offer its own nuanced experience of a new physics programme. Academic staff stationed in various parts of the university came together to form a physics team. This was complemented by an Industry Advisory Board, which was established to help develop a modern degree that had relevant, current physics applications and employability skills at its core.

At present, the course is offered as a three-year BSc in Applied Physics, and a four-year MPhys version will be offered from September 2015. The BSc has compulsory modules covering the essentials of physics, and final-year options reflecting the research interests of the academic staff, including RF and microwave physics, health physics, climate change and energy resources. Further options are available in particle physics, modern astrophysics, and quantum theory and relativity theory. This option-based structure allows students to customise their degrees and, when combined with the final-year 40-credit project, enables them to spend more than half of their time pursuing their particular interests in physics.

Problem-based learning has been an effective teaching tool, highly valued by academic staff, employers and students. It has become the core of laboratory work during the first two years of the degree, and has informed the development of other units. Recognising the motivational impact that career aspirations can have, and that physics students had a very limited idea of their own employment potential, a teaching unit was designed for the first year to motivate students and inform them of potential careers through a programme of industrial visits, invited lectures and related university work.

A particularly successful link has been established with the medical-physics department at Queen Alexandra Hospital in Portsmouth, and a number of students have undertaken successful projects through this link. Another project undertaken with the Defence Science and Technology Laboratory (Dstl) (environmental) helped a student to gain a place on the national Medical Physics Training Programme.

Portsmouth benefits from the existence of the university’s internationally recognised Institute for Cosmology and Gravitation (ICG). Physicists at the ICG help to teach the mathematical content of the new applied physics degree, placing strong emphasis on developing mathematical physics proficiency across the first two years. This teaching approach is contextualised in terms of physics problems, and is customised for students who may not have the high level of mathematical skill demanded by more traditional physics courses.

Interestingly, the success of the applied physics degree has led to the development of an MPhys

in physics, astrophysics and cosmology, reflecting the strong interest that students develop through interaction with staff in the ICG.

Academic staff do not hold to a notion of “fixed intelligence”, or that A-level scores alone are always good indicators of future performance. They take a broader view of entry requirements, and strive to identify those potential students who can rise to the challenge of completing this carefully constructed curriculum with its attendant teaching and learning approaches. Occasionally, this may result in a slightly elevated drop-out rate, and they intend to monitor this during subsequent cohorts, but they are able to testify from experience that many students, given the appropriate opportunity, can flourish and progress to the highest levels in employment and research.

This new degree registered its first students in 2010, and since that time two cohorts have graduated: five graduated in 2013 and 21 in 2014 and 2015.

The course at Portsmouth gives students who may otherwise have been discouraged from studying physics by the barriers to entry, the opportunity to develop into first-class physicists. This reflects a key feature of the National HE STEM Programme. As a result of the introduction of the new Applied Physics degree, there are now over 90 students studying physics who otherwise may not have had the opportunity, and this is expected to grow with the introduction of further related degree programmes.

St Mary's University, Twickenham

St Mary's boasts a proud history dating back to 1850, when it opened as a Catholic college for the training of teachers. Originally based in Hammersmith, it moved in 1925 to its present home at Strawberry Hill, Twickenham. In the past, its qualifications were validated by the universities of London and, later, Surrey. It was granted degree-awarding powers as a university college by the Privy Council in 2006, and gained full university status in January 2014. It provides qualifications across a range of subjects through its four academic schools: arts and humanities; education, theology and leadership; management and social sciences; and sport, health and applied science.

St Mary's University designed a new applied physics degree, which is a three-year BSc Honours course, with an emphasis on metrology; it is delivered in association with the nearby National Physical Laboratory (NPL), and is partly taught on their site. It recruited for the first time in the 2013/2014 academic year, with an initial cohort size similar to Portsmouth's and with a view to becoming a staple offering to those studying within the well-supported teaching environment of St Mary's University.

It covers many of the topics found in conventional physics degrees, but also offers a range of options in modern applied physics, such as nanotechnology and advanced materials. During their first and second years, students undertake a series of group-centred, problem-based learning activities supported by the usual array of lectures, tutorials, workshops and laboratory classes.

NPL has links with a range of universities, mainly in the form of research partnerships. The partnership with St Mary's, however, aims at delivering a high-quality undergraduate experience. This will be reflected in the project work available to students, and is expected to be a major positive feature of this course in the years ahead.

Work continues to expand the size of the cohort into the second and subsequent intakes, and staff are working to attract students who will demonstrate a commitment both to the course itself and to their own futures as practising physicists.

Integrated-sciences programme

Natural sciences at the University of Leicester

The University of Leicester set up the Centre for Interdisciplinary Science in 2004. The Centre was conceived to deliver a programme responding to a perceived national need for more broadly educated scientists.

The integrated-sciences programme at Leicester is a pioneering degree programme in the natural sciences, work on its design having started more than a decade ago at this well-established department. It is interdisciplinary in nature, rather than multidisciplinary, with four core sciences (biology, chemistry, earth sciences and physics) being studied across all three years of the BSc course. This is supported throughout by appropriate studies in mathematics, computing, and broadening skills in research, learning and presentation. Laboratory classes are followed in the four sciences across the three years.

Core modules are taught sequentially by problem-based or research-based learning activities; the modules are not borrowed from other courses but are specifically developed for the integrated-sciences programme. Each module is truly integrated, involving more than one discipline and focusing on a particular issue or area, such as nanoscience, climate change, forensics or astrobiology. Nevertheless, the fundamental science content is at the same level as traditional single-subject science courses.

Academic staff from participating departments were invited to propose salient topics from their disciplines; these constituent elements were then reverse engineered, paying due attention to prerequisites, and assembled into problem-based modules for delivery in the earlier years of this degree programme. In doing so, the course designers were attempting to move away from the restrictions of discipline silos and traditional delivery methods towards a more student-centred learning approach with a wide-ranging curriculum.

While interdisciplinarity is considered important at the research level, the course managers believe that it has yet to make a significant impact at the undergraduate level, and this integrated-sciences programme is an attempt to address that issue.

Currently, the programme is offered as a three-year BSc degree and as a four-year MSci degree, with variants of a year or semester abroad being available, and serves some 50 students. Although the fixed core takes up most of the available credits in each academic year, some flexibility is possible, and a pathway is available to transfer to a single-subject degree after two years, having followed a slightly different second year.

Although originally devised as an opportunity for widening participation by recruiting from lower A-level grades and non-standard qualifications, changes in the university's local admissions policy have resulted in it being regarded as something of an elite programme, appealing to AAA/ABB students. However, the programme strives to accept students from a wide background on to this degree course.

Combining contextualised teaching, research-led learning and transferable skills training prepares graduates from this programme for working lives in the commercial world, academic research, environmental research and stewardship, the media and the teaching profession.

Common themes

While devising new and exciting physics degrees in terms of content and delivery, course designers choose to retain some elements of more traditional degrees. Teaching occurs through a mixture of lectures, tutorials, workshops and laboratory classes. Assessment is by a combination of continuous assessment and end-of-module examinations.

There is a significant emphasis on project work – both individual and group projects – where a second-year project is followed by a more substantial third-year project, often with input from an industrial or commercial advisory partner. In both project work and exercise classes or tutorials, there is an increased emphasis on presenting students with a real-world physics problem that they have to investigate by applying their newly learnt physics knowledge and their nascent research skills. Analysis by computer modelling and consulting appropriate sources including primary scientific literature is expected, as is a near-professional standard of presenting results and conclusions in public.

Some modern topics finding favour among course designers are: health physics; aspects of nanotechnology; cosmology, astrophysics and astrobiology; climate change; energy generation, distribution and security; forensic science; and advanced materials.

Students from these courses are successfully securing PhD positions (at their home and other universities); entering MSc courses of study; enlisting in medical-physics training; entering the teaching profession; and engaging in typical graduate employment roles. Academic staff frequently refer to the enhanced maturity that students develop as they progress through these courses, and describe how elevated their sense of aspiration becomes as they meet and work with people from industry and other organisations outside of the university.

Pitfalls and rewards

Designing and implementing a brand-new physics degree where no comparable degree, or even department, currently exists, is clearly a major undertaking that requires hard work and dedication over a long planning period. By common consent, interaction with the wider physics community, facilitated by bodies such as the IOP and by the National HE STEM Programme, has played a significant role in the development of these new courses.

It is often said that establishing a new programme as a bottom-up initiative can be more challenging than implementing one using a top-down approach. The initial problem being that academic staff involved in the design process are also fully engaged in other areas of the university. Therefore, the key is discovering like-minded enthusiasts among the academic staff who are prepared to join the design phase and who will work to develop the time and resources required to establish a new programme. Some are of the view that this may not always be possible without external support, and the enterprise can be vulnerable to key failure points such as people leaving, retiring, being promoted and even heads of department or senior administrators changing.

These courses are set up to be innovative in content and delivery, and some effort has to be made to avoid the tendency to “regress to the mean”, resulting in business as usual. Avoiding this regression requires careful management and staff development. A major problem is attracting sufficient students to these new courses (which are usually not accredited or recognised externally at the start), particularly in the first few cohorts, such that they do not attract excessive negative scrutiny in the early years due to general pressures on resources. Course managers realise that they need to be nimble-footed in promoting their courses and in securing advertising and appropriate publicity.

Maintaining and developing industrial contacts with a small staff can be demanding, as can be continually motivating a group of students embarking on a new programme. However, once established, the rewards for the designers and the wider department can be significant. A number of course managers note a renewed sense of mission that develops among the academic staff appointed to deliver these new programmes. Similarly, students attracted to these new courses tend to develop an almost “evangelical” zeal, and the strong sense of community engendered creates a supportive environment in which students and staff work closely together. Those who enter with modest qualifications and apply themselves diligently often turn out to be among the more successful participants in these programmes of study.

Another major reward is that physics degrees are now being offered at universities that were devoid of the discipline before the HE STEM Programme commenced. Currently, even at this early stage, some 180 to 200 extra students are benefiting from an advanced education in physics as a result of this national initiative – a constituency that would hitherto have been almost impossible to reach.

A major reward often mentioned from the perspective of academic staff is the final outcome – employable and successful graduates capable of developing into effective professionals in almost any field of endeavour. More than one course manager has mentioned the sense of pride that they and their colleagues feel in their student cohort as they progress through and finally graduate from these new courses.

Closing remarks

Course designers and managers declare that they have benefited from participating in the National HE STEM Programme and from joining, at various times, in the work of external groups mediated by the IOP and other professional bodies.

Such groups have included: Higher Education Group, New Degrees Group, Mathematical Modelling and Problem Solving Group, Industry Group Projects, HE STEM Curriculum Change Group and SEPnet (South East Physics Network).

Many course designers also benefited from recent pedagogical research in higher education available through the publications of the Higher Education Academy and the IOP. Through HE STEM funding and IOP facilitation, they were able to benefit further from meetings with colleagues at other universities where best practice could be communicated and successful techniques adopted from other programmes. This interaction with the wider community played a central role in shaping the learning and teaching methodology of the new degrees.

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