Science and Learning Expert Group

Institute of Physics comments to the Group

A full list of the Institute’s submissions to consultations and inquiries can be viewed at www.iop.org

29 September 2009
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Professor Sir Mark Walport  
Chief Executive  
The Wellcome Trust  
215 Euston Road  
London  
NW1 2BE

Dear Sir Mark,

Science and Learning Expert Group

The Institute of Physics is a scientific charity devoted to increasing the practice, understanding and application of physics. It has a worldwide membership of over 36,000 and is a leading communicator of physics-related science to all audiences, from specialists through to government and the general public. Its publishing company, IOP Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

Following the meeting we had on 18 September, the Institute is pleased to submit its views to inform the Science and Learning Expert Group and these are attached as an annex.

If you need any further information on the points raised, please do not hesitate to contact me.

Yours sincerely

Professor Peter Main  
Director, Education and Science
Teaching

• The major problem is the shortage of specialist physics teachers, which is highly unlikely to improve over the next decade.

• Realistically, much of the physics teaching up to KS4 will be carried out by non-specialists and it is essential to ensure that these practitioners are competent to the task. Our evidence suggests that the physics knowledge base of many of the non-specialists is very weak indeed. Current models for CPD are almost certainly unsatisfactory in this respect. Two possible ways forward are:
  
  o To use the model of the Institute’s Stimulating Physics Network, in which expert trainers go to the schools to work with teams. We believe this is the most effective method of working with all the non-specialists in a department on bespoke, subject-based issues. The pilots have led to a 33% rise in take-up of AS-level.
  
  o Some sort of requirement or incentive should be provided for CPD. The recent trend has been towards in-school CPD, which rarely involves subject specific activities. Such remarks are also true for specialist teachers.

• Usually, markets adjust to compensate for specific shortages but this does not happen easily in schools and colleges. Proposals for differential pay are usually opposed by head teachers and the unions. A possible, less controversial alternative would be to pay the student loan repayments of teachers of shortage subjects so long as they remain in the profession.

• Another method of providing an incentive for teachers would be to recognise their knowledge and expertise via some sort of Expert Teacher designation. The Institute is already developing appropriate on-line assessments and the professional bodies could well play an important role in such an arrangement.

• We believe that the current one-year teacher training course is insufficient preparation for teaching the sciences and that a longer course, perhaps including the first 2 or 3 NQT years, would not only provide greater subject specific training, it would also engender a culture of CPD.

• Clearly, there are many local success stories in persuading students to take science A-levels and to progress. These are often based on talented and charismatic teachers or groups of teachers. Possibly the best way to roll out such excellence would be to set up clusters of schools. However:
  
  o One should be very careful indeed before suggesting that some schools take responsibility for teaching in a region; such a proposal would risk leaving many of the schools without any sort of physics specialist leading to serious problems teaching physics pre-16.
  
  o In principle, specialist schools and colleges could act as cluster centres but, currently, there is no guarantee that such institutions have specialist science teachers and there is evidence that that do little better than average in achieving A-level participation and success.

• There is an ongoing problem of recruitment: we need 700 ITE per year to stand still. Currently we get just over a half of that. So we are losing physics teachers at a rate of more than 300 a year. Numbers are topped up to some extent by entry from physics enhancement courses and SASP. There is also
an issue with retention. It is hard to get data by subject. However, 50% of new teachers leave within their first five years.

- Mentoring programmes can help retention. There is now a national pilot; however, it has been implemented at a low cost and we are not convinced it will be as effective as it needs to be. Whatever the result of this pilot, we would not want to see this sort of scheme die.

**Access**

We are concerned about access for students to teaching that will encourage them to take physics to A-level and beyond. In 2007, there were 2687 centres entering students to A-levels. Of these,

- 470 (15%) entered no candidates for physics; the proportion was the same for maintained schools (269 out of 1748);
- 30% entered two or fewer candidates;
- 70% of candidates came from 30% of centres; these schools had 10 or more students sitting A-level physics.
- The number of centres entering 15 or more candidates was 457; of these, 118 were independent schools, 236 were maintained or voluntary aided schools and 103 were FE colleges.

The Institute will be doing more work on the first and last bullet points. However, based on the research of Smithers and Robinson (http://www.buckingham.ac.uk/education/research/ceer/pdfs/physicsprint.pdf and http://www.buckingham.ac.uk/education/research/ceer/pdfs/bktrend.pdf), it is reasonable to characterise the schools with zero and large set sizes. The former is unlikely to have any specialist teachers, there is little culture of physics within the school. Conversely, schools with a high uptake will have a good complement of physics teachers; physics will have a clear identity from late key stage 3 and physics topics will tend to be taught by a physics specialist.

We do not yet have statistics for progression from 11-16 schools to FE colleges to take physics; however, we know that the problem of a shortage of specialist physics teachers is worse in 11-16 schools than in 11-18, so it is likely that progression is worse.

The worry about the first two bullet points above is that there are schools that appear to have lost (or are losing) physics altogether and students are not given the opportunity to do physics. The third bullet indicates that, in the right circumstances, physics is popular and students choose it.

It is possible that the situation is being exacerbated by raw league tables (see below for a discussion on grade severity); in particular, that there is no incentive for head teachers to maintain a strong presence of physics specialists in a department – particularly when they are hard to recruit. Therefore, we would like to see a requirement that every school has at least one physics specialist teacher. There is a stretch and challenge issue here. Leaving aside the issue of grade severity (for the moment), physics (and maths and the sciences) provides a route by which a certain kind of aptitude is nurtured and challenged within the curriculum. At least 15% of schools are not offering this opportunity to stretch their most able scientific and mathematical students.

**Curriculum**
The majority of university admissions tutors in physics and engineering insist that a major problem with their intake is that they have not been taught physics in a mathematical context. Within the current system, the only plausible routes to remedy that situation are either to modify the A-level curriculum drastically, which, without a very strong campaign, is unlikely to occur until the next revision of A-levels, or to introduce a new Mathematical Physics AS qualification. The Institute has been considering following the latter route.

There has undoubtedly been far too much change in STEM education over the last few years, the great majority of it piecemeal and incoherent. Despite this activity, there has been no attempt to develop a coherent, modern curriculum for the sciences. There is an urgent need for a reappraisal of the whole cradle-to-grave science curriculum.

Practical work is an essential part of science and plays an important role in enthusing students. Non-specialist teachers can often struggle in this area. A barrier that exacerbates this problem is the shortage of appropriate technical support.

The Institute believes that there is too great an emphasis on knowledge in primary schools and that there should be far more activity that gives the pupils the opportunity to appreciate the excitement of science and to gain some idea what the process of science means. Recent obsession with league tables and the like tends to militate against such an approach. However, there is a very strong need for good CPD for primary teachers, who are rarely graduates of science disciplines and almost never physicists.

The system has not yet worked out the best way to accommodate and educate those students who learn better through application rather than the more abstract route of A-levels. The diplomas could have been an opportunity to address this omission but the rigidity of their structure and, in the case of the science diplomas, confusion about their purpose have been a great disappointment.

A related point is the importance of distinguishing between education and training. One cannot apply knowledge without having it and the best preparation for a wide range of STEM careers is a thorough grounding in mathematics and the sciences. Sometimes, in an attempt to introduce courses with “relevance”, QC(D)A has lost sight of this principle. For example, a recent GCSE in Environmental Science would not have allowed progression to A-level sciences and, paradoxically, anyone taking it would have had the door closed on that topic as a possible career. Qualifications in law, sociology, psychology etc attract many students away from the sciences (see below) but are not used by HEIs as specific entrance requirements even in the named subjects.

Physics should have a distinctive place in the curriculum from GCSE (and preferably before). The invention of a subject called science has led to a loss of identity of the sciences, not just amongst students but school leaders; often they have little idea of the differences between the sciences and therefore the need for specialist teachers.

Assessment

There is no doubt that there is too much assessment in schools and that Curriculum 2000 is responsible for much of this congestion. Many schools give students time off to revise for AS examinations and even for resitting particular modules. This time is removed from the curriculum. In addition, the measures used in league tables mean there is an enormous pressure on teachers in the state sector to teach to the test; in other words, the system tends to prevent any stretch for the better pupils.

There is no doubt that GCSEs, in particular, and A-levels are not stretching the better science students. The Institute believes strongly that stretch should be an
integral part of the assessment system and not be seen solely in terms of enhancement. Students must be able to show their worth within the standard assessment system.

- There has been a great deal of discussion about the maintenance of academic standards in public examinations. While we do not wish to be drawn into this politically charged debate, we would point out that the current system has almost no drivers that act to maintain standards but a large number that could act in the other direction. Students, schools, admissions tutors, awarding bodies all benefit from grade inflation.

- The role of awarding bodies within the assessment system is questionable. They are commercial organisations that benefit solely in terms of the number of their specifications they can sell to schools. There are neither any requirements to offer diversity nor any real mechanisms to maintain standards. Teachers will often choose a particular specification because the number of grade As it produces. There are very few mechanisms to compare standards, even within an awarding body, and essentially none at all between them.

- A recent study commissioned by the IOP and the Royal Society on behalf of the SCORE partnership (http://www.score-education.org/2projects/relative_difficulty.htm) has demonstrated that the sciences have the highest grade severity of all A-level subjects (note that this cannot be explained by differences in aptitude, which was taken into account by the report). In addition, the Institute has very strong anecdotal evidence that students are discouraged, often by teachers, from taking science subjects when they would probably get a better grade in another area. Once again, the drivers act to prevent students taking STEM subjects.

- Currently, schools and colleges are publicly assessed in terms of their examination results. It would make far more sense to rate them in terms of their participation and progression rates in key subjects, which implicitly takes into account performance. Participation at A-level and, say, university admissions, could be among the indicators. Then there would be an incentive to recruit to strategically important subjects rather than to ensure a high global average of A-Cs. Many independent schools effectively use this as an incentive and it is noticeable that they tend to introduce much more stretch than does the state sector.

- Largely for reasons of fairness and consistency, there has been a shift away from course work towards formal examinations. While we understand well the reasons for this shift, it does have unfortunate pedagogical consequences and there is already quantitative evidence that it disadvantages girls. We would urge the development of teacher-based assessment that preserves the good features of course work while reducing the opportunities for abuse of the system.

Ethos

- We believe that an essential feature of high quality STEM teaching and high participation is the presence of a coherent science team in institutions with supportive cultures. As an important example, we know from our own work that he schools that are best at encouraging girls to do physics all tend to have a “can-do” attitude across the whole school, which works against the gender stereotyping.

- We have found from our work with non-specialist teachers that they tend to avoid thinking much about promoting physics because they lack confidence and may even fear the subject. Where we have managed to make a difference in schools, it is by engendering a physics atmosphere among the teachers, where they start to feel interested in and excited about the subject.
Pull

- The HE market is basically dysfunctional in that university funding for teaching is largely driven by student choice but that choice is based neither by the requirements of the economy nor by any realistic appraisal of career paths. The effect has been massive growth in subjects such as drama, media studies, psychology and forensic science, while employers bemoan a shortage of STEM graduates. Two measures might help improve the market information:
  - Employers, government and other commentators must continually stress that there are good jobs for STEM graduates. To hear the prime minister and the head of the CBI promoting this view does have a real effect on pupils and parents and is almost certainly one of the major factors in the recent upturns in A-level numbers.
  - There is an urgent need for an independent guide to career prospects for graduates in different disciplines. In general terms, the average worth of graduates to a market economy is measured by their remuneration. Government has the data, for example via the Student Loan Company, and yet no such guide currently exists.

- On a related point, enormous efforts have been spent recently in developing careers advice for young people and it is indeed true that the current situation is very poor. However, it is absolutely essential to target careers advice intelligently and to take into account the mindset of young people as they progress through education. The majority of young people are vague and impressionistic about their careers, often until graduation. Too specific advice can be counterproductive and the emphasis should be on keeping doors open. In addition, such factors as the perceived geeky image of science can be a far more compelling reason not to do it than any potential career path in the distant future.
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