The Physiological Society's response to the Smith review on post-16 maths in England

What is your view of the mathematics and quantitative skills young people have when they enter employment or higher education?

As A-level Maths is not an essential requirement for study in most HE bioscience courses, many HE entrants will not have studied maths for the previous two years. This is a recognised problem and the Advisory Committee on Mathematics Education (ACME) has published two papers outlining proposals for post-16 maths: http://www.acme-uk.org/news/news-items-repository/2012/12/acme-proposals-for-post-16-mathematics

These recommendations may be useful in helping to identify ways of ensuring A-Level students have the basic numerical and statistical skills they need to progress well in HE.

What basic level of mathematics and quantitative skills do businesses and higher education need school leavers to possess? Do leavers meet those levels now?

HE entrants need to have a solid grasp of numeracy and to have the confidence to put this into practice. Currently many students, even in the sciences, are frankly frightened of anything to do with numbers. HE entrants need to be comfortable about basic mental arithmetic as well as having some grasp of using symbols in equations. While advanced maths and statistics can be taught at University, the following have been identified as appropriate preparation for HE bioscience courses:

- Ability and confidence to work with numbers
- Ability to interchange units
- Ability to use and manipulate simple equations (such as estimating drug doses)
- Ability to estimate, mentally as well as with aids
- Understanding of appropriate accuracy and of significant figures
- Understanding that measurements should be repeated to increase reliability
- Understanding of descriptions of data including types of averages (mean, mode etc.) and measures of variation (mean, median etc)
- Understanding that statistics usually only deals in probabilities (e.g. inferring information about populations from samples) and understanding what probabilities mean

Are there sufficient school leavers with advanced mathematics and quantitative skills for the needs of business and higher education?

The experience of most university teachers is that most school leavers are not equipped with the necessary quantitative skills or confidence to perform quite basic numerical tasks, let alone possessing advanced mathematical skills. As stated above, the latter is not required for university entrance but the former definitely is.

Does post-16 maths provision need to change to better meet current requirements? How?

In general, we believe that supporting good teaching and increasing the time devoted to tasks involving numeracy (e.g. finances, data handling, problem-solving exercises) would increase students' confidence in using basic arithmetic, simple equations and basic statistics. We are pleased to note that the new A-level Biology descriptors across all exam boards include data handling, graphical representation and basic statistical parameters such as mean, mode and median. Perhaps it might be useful to recommend a minimum number of teaching hours in A-

level Biology that should involve such tasks, and clear statements about the non-negotiable core nature of such material. It is imperative that A-level students cannot bypass numeracy and still get top grades.

Schools don't necessarily have to teach the details of (for example) quantifying error and biological variation but it would be useful for students to understand that repeat measurements of biological and medical variables generally yield a much greater range of values than in the physical sciences (e.g. height or heart rate of pupils vs the length of an iron bar). A simple experiment like this that compares such variables could lead on to concepts such as distributions, averages, variability in data etc.

How do you see those requirements changing in the next 5-10 years?

Computational and engineering mathematics are having an increasing role in understanding biological processes and clinical developments. Lots of fields, such as genomics, population medicine and 'big data' in general, are requiring ever more sophisticated statistical methods, both to extract valid results and to minimise the risks of false inferences.

How should post-16 maths provision change to meet those future requirements?

School curricula need to change so that pupils at all stages handle numbers and become comfortable and confident about doing so. That must not stop at 16. Post-16 curricula need to embed scenarios that are familiar to pupils while having some numerical component; that could and should apply to all subject areas, but clearly with more emphasis in the sciences and social sciences than in the arts. It should not be a case of adding in new subject areas, but in using existing areas to illustrate how numerical analysis (whether arithmetic or statistical) can clarify the validity of conclusions. It is very important to include context in numerical analysis, for example using examples of data generated by students themselves; examples taken from scientific reports and the media – ideally selected by the students. This brings maths and statistics 'alive' for learners and reinforces their role in 'real life' situations rather than as abstract, dry and difficult subjects – which is the way they are often perceived.

Is there a case for more (or all) students to study maths after the age of 16? To what level?

It is essential that all students from reception to PhD expect to use numbers to help them understand all aspects of the world around them. Specific mathematical skills can be taught to students who can deal with numbers; but it becomes extremely difficult to do that with students who have been able to hide from anything numerical since GCSE – one would hope that achieving this standard is something that a leading economy and scientifically prominent nation would require.

Please add any other comments or evidence you would like us to consider.

As hinted above, a major issue with current curricula is that they allow students to hide from numbers. Once students learn that they can get by without having to be numerate they expect to be able to continue to do so – and by and large school and university courses allow them. It is worth emphasising that the political weight currently given to student feedback (e.g. inclusion of student feedback in the NSS metrics that will underpin the proposed Teaching Excellence Framework) motivates against curricula including material that is unpopular with many students – numeracy being one such. That needs to change.

In relation to some of the points raised in this response, The Physiological Society is currently developing a Physiology MOOC that will embed many of the mathematical and statistical skills outlined, with the aim to increase potential HE entrants' exposure to, and confidence in using, these skills.