A Need for Numbers?

Executive Summary

- Post-16 maths and stats. We agreed work needs to be done on strategies that encourage continuation with some form of mathematics for those who are not going to be doing A Level.

- Compulsion. Unless universities start insisting on certain kinds of quantitative preparation for HSS degrees, change is less likely. Participants described a virtuous circle in which employers say 'we want you to graduate with this particular qualification', the professional bodies and subject specialists specify entry requirements, then schools invest in teaching methods and quantitative skills.

- Information sharing and communication. Universities need to talk more and more directly to examination boards – and employers to higher education, universities to schools.

- Signals. Universities should specify more clearly what they want on the part of students going on to study. Employers should signal more clearly, too, so students see that QM is beneficial and relevant in the labour market. Higher education needs to signal to government that methods and statistical literacy within HSS secures the ends it has looked to STEM subjects to meet. Higher education should signal to employers that HSS students are acquiring skills they normally associate with other degrees.

- Inside or outside? Embedding methods and numbers in the subject matter of HSS disciplines is likely to more effective. Students tend to be interested in substance so the more relevance methods to the subject matter of the respective disciplines, the better.

- Collaboration. Teaching QM and raising statistical literacy is expensive. Web-based sharing of technique and practice could reduce the cost.

Foreword

Nigel Vincent: The Comprehensive Spending Review awarded the British Academy £5 million over four years to promote language and quantitative skills. The discussion and proposals described here are germane.

Quantitative skills are more than just statistics: they embrace all mathematical methods. In linguistics for example, there are people who work on formal modelling of languages as a way towards computer data processing and so on, and those are not necessarily statistical techniques but they are important skills that people have.

Traditionally the British Academy has been associated with post-doctoral studies, from fellowships through to very senior scholars, but we recognise that if we want to change national agendas in both statistics and languages, we have to get in as early as possible in the educational cycle. In languages for example, that has meant talking to primary schools. Today's thinking about how undergraduate programmes might develop is similarly part of that reflection on the earlier stages of the educational process.

David Rhind: In chairing the Nuffield Foundation and as a director of the UK Statistics Authority I have witnessed the lack of quantitative skills amongst the population and, I have to say, among researchers. The statistical literacy campaign **getstats** is something we place a great deal of reliance upon. This is a huge task but we are going to make it better.

Nuffield does not think that only quantitative research or analysis matter, or that conceptual, theoretical or qualitative work is unimportant. Our view is that the capacity shortfall in the quantitative social sciences is significantly greater than in other areas and that is why we want to do something about it.

Our concerns about the quality of quantitative skills in the higher education workforce were not prompted or precipitated by John MacInnes's excellent report for ESRC (1) but they were certainly buttressed by it. The problem clearly starts much before undergraduate days. Every time I feel too cheerful, I read *Is the UK an Outlier?* (2), an international comparison of upper secondary maths education. The situation it describes – recognised in Parliament and in the Vorderman Report (3) – is one of skills deficit among UK students, including those in the social sciences and humanities. Fewer than 20 per cent of students in England and Wales take any mathematical qualification, including modular ones, post 16. The situation is a bit better in Scotland but I do not think it is anything to be complacent about.

Schools of course feed into the university domain. The deficit hampers the ability of many doing social science at university from reading and understanding, let alone carrying out work that sheds light on social selection effects, or (in any precise sense) interactive causality and a whole range of other things we would expect and want to have done.

We are taking school-level work forward in partnership with the SCORE maths in science project. This is looking at mathematical content in A and AS Level biology, chemistry and physics. Nuffield is funding similar work on A and AS Level business studies, economics, geography, psychology and sociology, findings of which should be out soon.

Nuffield will shortly be launching a competition (with a valuable contribution from ESRC) to promote quantitative methods capacity building for undergraduate social sciences. We will fund five to ten centres of excellence to create a new critical mass of social science undergraduates from disciplines other than economics and psychology. The programme will include bursaries for summer schools and internships and money for additional teaching resources. (Sharon Witherspoon, Deputy Director of the Nuffield Foundation can supply further details: contact rlalemontes@nuffieldfoundation.org).

I am delighted that the British Academy and the Royal Statistical Society, in the form of **getstat**s, have taken such an active role. The Nuffield Foundation is glad to be part of this.

Introduction

There is a generic deficit in quantitative capacity in our country and specifically, in the preparation of many students who study social science and humanities subjects. However, there are signs of change. Social scientists talk of turning away from a relativist, so-called postmodern approach, towards one based more upon an understanding of a complex reality through quantification and numbers. A new formula for funding university study might lead to revision in course content and admissions policies. The Education Secretary wants changes in the mathematical content of schooling in England. (The education systems in Wales, in Scotland and Northern Ireland are of course differently organised.)

If, across the arts and social sciences, only one in five students arrives at university with more than a GCSE maths qualification, in economics, it is nearly four out of vie. Numeracy is evident in pockets such as social demography, bits of geography and, to a certain extent, psychology. Appendix 2 offers a resume of the 'quantity of quantification' in HSS subjects, based on the Quality Assurance Agency's recent benchmarking exercise.

The problem – 1: John MacInnes

It has three key elements. The first is the skills with which university students leave school; the second the attitude students themselves have towards those skills; and the third is what happens when they get to university and what the university curriculum is.

Most will have spent two to four years not doing any maths at all since they finished their GCSE study and their skills naturally will have atrophied. Even first-year psychology undergraduates who are, if anything, more numerate than the rest of HSS students, struggle with basic arithmetic and algebra. – understanding where the zeroes go after a decimal point. When we try to teach students things that use simple maths as a vehicle, they get distracted by the maths that they are no longer fluent in.

As well as skills attitudes to numbers matter. Students do not have faith in the relevance of numbers because we do not give them enough good examples of how numbers can be used imaginatively and critically to tell a story. In social science (outside economics and psychology) methodology courses account for, on average, about 20 to 40 credits (out of 360-480 credits in total). In other words, they are something like one tenth to one twentieth of a degree programme. Numbers are too often seen as the preserve of people who can do very sophisticated things that we ourselves cannot understand and just have to take on trust. So students concentrate on other things. They say 'what I am good at and what I am taught repeatedly within most university curricula to be good at is developing language: to articulate different arguments, to weigh different arguments, to follow the logic of arguments and so on.' In other words, all of the skills that we repeatedly train students on when we get them to write essays.

Students take substantive courses that routinely do not pay enough attention to the use and exploration of quantitative evidence. They may then do a methodology course where they are taught basic social statistics. They see these options as marginal, as indeed they are; they approach them with little confidence in their own ability to make a success of them and with little faith in their relevance to the other things they come across in their curricula. No wonder methodology options are almost universally unpopular. As university funding alters, students increasingly see themselves as customers and customers are not likely to 'buy' a product they do not like.

Other weaknesses in existing courses include generalizability. How do we know whether research that is being done in a limited number of cases is a sample or whether it can be generalised to the rest of the population? When do we know when evidence is scientific as opposed to informed commentary or journalism?

Too much attention is paid to primary data collection and not nearly enough to analysis of data that has been collected by others. The revolution during the last 20 years in IT and the availability of different kinds of data and the ease with which it can be accessed is not being reflected in university courses.

What to do

The first thing is embedding approaches to quantitative evidence across university curricula and bringing them out of what has really become a ghetto of methodology courses. That in turn requires building staff capacity. It is not just the students who have unhelpful attitudes towards numbers, very often those are shared by university staff who themselves are uncertain about their own skills. Professional associations have to revise and make more stringent the benchmarks within quantitative research methods.

We need to address fear of numbers, starting with the school curriculum and, especially, pathways after 16. What happens to students who do not do an A-Level in schools after age 15 or 16? What do we do to keep up and reinforce the maths skills that they have gained in GCSE? Students need to see quantitative methods as relevant and necessary. These skills are not only useful for HSS students but because they will make a difference in the graduate labour market. Jobs make QM skills worth having – with that message we have a chance of turning attitudes.

The second issue is a problem that we have for years faced in the social sciences and life sciences – but shared across the STEM subjects -- which is students' ability to apply such maths knowledge that they already have to different contexts.

With support from the funding councils, Nuffield and the British Academy, the ESRC has put about £2 million into projects that introduce innovation into the undergraduate curriculum and which develop staff capacity in training in research methods. But we also have to think about a separate, graduate-level qualification in quantitative methods, one that could signal to employers that its holders have basic skills in quantitative analysis: the kinds of skills that they might otherwise look towards an economics degree to provide. If such a qualification was, for example, endorsed or regulated by bodies like ESRC, the British Academy or the Royal Statistical Society, it could carry weight with employers.

The system tends to define core mathematics competencies, the ability to use and handle quantitative evidence, to digest quantitative evidence and to present it in a coherent way to different audiences as 'STEM skills'. But they are not the prerogative of science and technology subjects. Here is a message to get across to government: the humanities and social sciences can play a role in developing a much wider base of STEM skills within the general population. If we can get that across to policy-makers we might be able to channel more resources towards developing quantitative method skills among graduates.

The Problem II - Roger Porkess

There is a total mismatch in the system between what the school system is providing and what higher education needs. And what employers want. For the Mathematical Needs report (4), Hugh Kyffin synthesised from what employers said the sort of maths that they would like done. The list is interesting because it is nothing like anything that is really on offer at the moment: mathematical modelling, use of software packages, costing, performance indicators, risk and quality control and statistical process control.

It is not a curriculum but maybe it is a starting point for growing the new courses that are going to engage people post-16 in forms of maths that they will to see as relevant to them. They will not just see it as doing the same old stuff time and time again, but as what employers really want.

We need to know more clearly what higher education would really like. We are not talking about maths higher education – maths is looked after and there are lots of people going on to do maths at university at the moment. What sort of thing would you like in the social sciences: is it the same as this, is it different, or does it intersect with this?

In primary schools, because primaries have one teacher teaching everything, it is easy to do cross-curricular work; they will take a problem and do the analysis, the data collection and the

presentation. They are not doing sophisticated maths with it, so their programme does not include data analysis but (in the threefold data handling cycle) does include data presentation and collection.

With GCSE you have a totally different perspective. The only statistics in GCSE comes under data presentation. Officially schools all do the full cycle – it is written in the syllabuses. But because it is not examined it is not done.

A-Level offers a little bit of data presentation, the maths of statistics but none of the problem analysis and none of the data collection. Yet there are some subjects which actually do a full cycle. Psychology for example. Economics does not do data collection but tends to use secondary data. Geography does; the other subject is biology.

Yet if the problem really lies with what is happening in schools, this is a time for some optimism. Michael Gove has accepted all of the Vorderman recommendations. The government says it intends to move towards everybody doing maths post-16 in school. That is a huge shift in direction.

Discussion

It can be done

There has been a 'huge expansion' in the use of quantitative methods in several areas, including history, aided by improvements in data collection thanks to IT. In sociology, the professional body (the British Sociological Association) unanimously endorsed the sentiments of John MacInnes' report 'both in the sense of the current deficit within sociology, the reasons for it and the need to do something about it'. However, in (human) geography 'we have to prove that it is sensible to do quantitative analysis; we have to compete with

Students not liking a course is 'crucial' when they are being cast as consumers and data from the National Student Survey determines the fate of courses and the flow of funds. Research methods courses are not popular. They are perceived as difficult. Some are 'actually being reduced in terms of their quality and content in an attempt to make them easier. Everybody is too paralysed to introduce something that students may find unpopular.' Courses offer a wide range of alternatives [to numbers and methods] that students 'increasingly see as more relevant to them as individuals and to their view of society'.

Also, cooperation between the professional associations in social science is 'incredibly difficult to reproduce within particular institutions'. Because, in many places, relations between departments are set up on a competitive basis.

'**All the little b****** s have got to do it. Basically'**

But cooperation between subjects at the level of learned societies might (usefully) become a 'cartel'. We need to assert the intellectual authority of subject specialists, which would strengthen if disciplines banded together. Subject specialists have to be prepared to say, forcefully, 'the requirement for this programme will include A, B and C in terms of stats and quants and so on and so forth'. Such statements of purpose – expressed in terms of required courses or perhaps an assessed qualification in statistics or methods -- would have a recursive effect on schools,.

The success of economics and psychology in incorporating maths and quantitative methods is exemplary. Even with unenthusiastic students ways can be found to make them enjoy numbers and methods. 'Contrary to their expectations students often evaluate such courses very positively because they know that they have learnt something.'

Sometimes [in psychology] students 'feel there is safety in numbers and that courses that involve statistics have a kind of solidity to them that can actually help them get a clearer sense of where they are in their performance.'

If that view was disputed, participants from HE seemed broadly persuaded that – in John MacInnes' phrase 'embedding' numbers, statistics and methods within the subject matter of the disciplines was most effective. In history, say, teaching statistics around a dataset could be better used worked better than teaching statistics 'straight'.

If staff have the confidence to teach QM 'across' their disciplines, it permeates more. Rather than just having a quantitative methods segment which they have to pass, students keep meeting QM as they go through their programme.

Who teaches?

But who gets involved with teaching QM or stats to social science students? Most teachers of stats and quantitative methods in university social science are junior. Professors don't teach such courses; they teach they teach very advanced quantitative methods. 'This divorce between research excellence and teaching excellence does not help.' The ESRC should make it a condition of grants for distinguished research professors to teach.

At issue is not students' mathematical skills. 'We can run on low-level maths. What we are interested in, in schools and in universities, is being able to persuade people about the relevance, the applicability and the value of quantitative methods.'

This view was heard more than once. 'It is not about maths, though I would love to teach students who can do algebra.' Rather, they need to be able to add numbers up. And understand the concepts. If a student can calculate a mean but does not understand what it is, that is no good.

But is it a matter of raising the mean level of quantitative attainment, making most people a bit better with numbers, or (from the quantitative perspective) to bring more people over to the dark side – to build up a cadre of quantitative experts? This participant preferred people who have expertise rather than merely statistically literate.

The contrary view is: you need a pool or foundation course made up of large numbers of students who are numerically prepared. From a large pool with a basic grounding in quantitative methods, the flow into 'expertise' would be enhanced.

Understanding – a paradox

If staff and students are ignorant of statistics and quantitative methods, how far can they understand material published in the professional journals when it is increasingly and rigorously mathematical? One response was that they don't. Excellent quantitative research produced in the UK gets offered to and published in top American journals. By not publishing in British journals, social scientists miss a chance to 'democratise' quantitative knowledge.

Perhaps editors of professional journals should be gathered together and asked to require authors to do more explanation of the techniques they are using; to explain in language which can be understood by the constituency that is reading them.

Employment

The ACME report showed employers are critical of the statistical sophistication of graduates. The general level of organisational decision making in the UK was diminished if HSS graduates lacked competence. One way forward would be to capture 'stories' from HSS students who have gone out into employment with these skills. 'Then it would not be just academics talking about how this is good in terms of employability and so on and so forth, but students graduating with these skills and feeding that back to their peers.' Employers, for example those on sector skills councils, don't grasp that quantitative capacity can be built up in studying HSS subjects other than economics.

A parallel education may be needed by government ministers, who need better to under the 'Stem-ness' of skills acquired in studying HSS. That is to say, if HSS students did more QM and stats, the national skills deficit they perceive might be filled.

Proposals

- The case was made for a four-year undergraduate masters that culminates with the first year of what is provided within doctoral training programmes in terms of research methods. That would also have the advantage of students being able to access undergraduate funding to do what is in effect a postgraduate qualification. It is something that is done as a standard across the sciences, and has not yet been developed in the social sciences. We now have the institutional means of doing it, by pushing Doctoral Training Centre work 'backwards' into the end of an undergraduate degree programme.

- A methods or quantitative qualification for HSS students, either free standing or offered as joint honours or in the form of a major/minor degree (politics with social research methods, say) . The counter argument was that some students would feel they are likely to more employable if they get a higher class of degree, and the prospects of that might diminish if they chose to do a methods course. Participants debated whether QM or numbers courses should be assessed. 'A non-assessed employability-oriented statistics course, which could also be badged in a sense in terms of a certificate given that it does not challenge the structure of a degree and its credits, might be one of the ways of actually getting the general level of undergraduate confidence in statistics developed, whilst also being attuned to what the reality of students as consumers might well be for us.' Alternatively, if employers placed a premium on it an assessed statistics course could become attractive to students. Experience shows 'students demand changes when employers say they want them. They are far more astute than we sometimes realise in that.'

Schools

Around 5,000 post 16 students take Freestanding Maths Qualifications – when in principle 'the market' for such courses is huge: there are between 200,000 to 500,000 students in an age cohort post-16 who are not studying any kind of maths. If university admissions staff started preferring FSMQs, the ball would start rolling. So much depends on recognition within the Universities and College Admissions Service. Another promising development are Extended Project Qualifications, within specific subjects such as geography, some of which contain data handling methods and statistics. Debate, in schools as in HE, is along the axis: free-standing or embedded. 'We can write the best methods modules in the world, but they will still be seen as pariah modules if we do not embed them.' A parallel debate is over assessment: unless a course is assessed, it may not be recognised by universities and in turn lack attraction for school heads and government.

An alternative route is A and AS Level, governed tightly by the exam regulatory system. But the signs are encouraging. The government [in England] seems likely to push post 16 maths. In Wales an increasing number follow the Welsh Baccalaureate Framework. Within that they carry on with essential skills, or key skills, which includes application of number. That said, of the six key skills, it is application of number is least likely to be followed when there are 'softer' options. In Wales two awarding bodies are talking about non A Level post GCSE Level 3 mathematics qualifications. 'What needs to happen now is admissions tutors to give credit to that. If they said 'we need three Bs at A Level for our subject, but if you have got a freestanding maths qualification unit, or if you have got the statistics unit we will drop that to two Bs and a C'. The upshot could be some universities seeking to distinguish themselves by asking for such additional requirements, leading to more stratification.

But, a warning note, the more the provision is diversified (with FSMQs and developments at A and AS Level), the harder it is for schools to provide.

Who should teach maths and stats?

In HE, as in schools an axis of debate is: whether to embed study of methods and numbers 'inside' a subject or providing it as an adjunct. Even those taking A Level statistics may be weak mathematicians in

terms of their GCSE result but may, if they are doing psychology, sociology or geography, find the statistics relevant and useful. But from within HE one participant bemoaned how 'your time is taken up so much with teaching stat 101 that you do not have time to teach the course on political behaviour, which demonstrates how these techniques are useful.'

Are teachers able? 'If we are talking about a novel way of conveying statistics and applying it to the 16 to 18-year-old cohort, it is not going to be done by maths teachers who taught maths in a traditional way. It has got to be done by people who have got confidence, and the overview of statistics and the discipline to do it well.' Even getting maths teachers to teach A Level statistics can be difficult 'because they somehow do not think it is proper maths. So it is not only social science experts feeling they cannot do maths, it is also maths teachers thinking they cannot do stats because they do not think it is maths.'

Do schools maths departments have the capacity to teach what could be a growing diversity of post 16 maths courses? Your average sociology teacher is not going to be teaching odds ratios for looking at social mobility at A Level. But we need to know that and start that discussion.

References

(1) ESRC (John MacInnes) Proposals to support and improve the teaching of quantitative methods at undergraduate level in the UK http://www.esrc.ac.uk/funding-and-guidance/tools-and-resources/research-resources/initiatives/qmi.aspx

(2) Nuffield Foundation 'Is the UK an outlier in upper secondary maths education?' http://www.nuffieldfoundation.org/uk-outlier-upper-secondary-maths-education

(3) Conservative Party: A world-class mathematics education for all our young people http://www.conservatives.com/News/News_stories/2011/08/Vorderman_publishes_report_on_maths_education.aspx

(4) ACME Mathematical needs report, http://www.acme-uk.org/news/news-items-repository/2011/6/launch-of-the-acme-mathematical-needs-project

Appendix 2

According to QAA benchmarking, statistical data are mentioned in descriptions of courses in Anthropology; statistical and numerical techniques in Archaeology; in Area Studies degrees, not at all; Art and Design, not all; Classics, not at all; Communication, Media, Film and Cultural Studies, no.

In Criminology, it is expected that graduates have 'an understanding of basic statistics, sampling, measures of significance and knowledge of the relevant software.' In Economics, there is a large amount in the QAA about the need for numeracy, that students should be appropriately trained in this regard and there is a lot of detail about what that requires, including specific mention of statistical understanding.

In Education Studies, on graduating with an honours degree, students will be able to collect and apply numerical data as appropriate, present data in a variety of different formats and so on. In English, no. General Business and Management, numeracy and quantitative skills including data analysis are required. In Geography, among other techniques, statistical and mathematical modelling. In History 'institutions are strongly recommended to make provision, where appropriate, for the development of at least one of these: visual and material culture, languages, the use of information and communication technology, numeracy and quantitative methods, archaeological fieldwork, archival study, skills associated with the study of other disciplines with which History has close links'.

Languages, no. In Law, students should demonstrate a basic ability where relevant and as the basis for an argument use and present and evaluate information provided in numerical or statistical form. Linguistics students should demonstrate understanding of data and analysis presented by means of graphs etc. Philosophy, no. Politics and International Relations: use communication and information technology for the retrieval and presentation of information, including, where appropriate, statistical or numerical information. In Psychology, a substantial mention of numerical and statistical capacities. Social Policy and Administration students should have an awareness of some of the more significant sources of data about social welfare and the main research methods used to collect and analyse data, data collection and research skills. In Sociology honours students should have access to the opportunity to do statistical and other quantitative techniques.