

Quantitative Methods in Geography

Making the Connections between
Schools, Universities and Employers



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Introduction

The skills deficit in quantitative methods in UK social science is well documented and the focus of substantial investment from agencies including the ESRC, the British Academy, HEFCE, HEFCW, the Scottish Funding Council, the Nuffield Foundation and the Higher Education Academy. The International Benchmarking Review of UK Human Geography (2013) states that “in many sub-disciplines it [human geography] is world leading, setting the intellectual agenda...” but identifies a “relative weakness in quantitative methods and GIS” due to “the relative neglect of quantitative methods in undergraduate and postgraduate training...”

Appreciation of quantitative methods does not begin and end with universities, however. Schools provide a student’s first exposure; career opportunities provide an incentive to practise numeracy and develop analytical data-handling skills. In a joined-up world there would be clear trajectories from the geography taught at schools, through the more specialised teaching of universities, to the needs and requirements of employers and the transferable skills they seek.

It is tempting to think that such links have been broken, pointing to the apparent marginalisation of quantitative methods from human geography as evidence. But should common wisdom about the poor state of quantitative methods teaching be believed? Are we really nurturing a generation of students that is sceptical about, hostile to, or simply afraid of using numerical approaches in geographical enquiry? If so, what can be done to turn the tide?

To answer these questions we undertook surveys of school teachers, university students, university instructors and heads of teaching within UK geography departments to gain a better understanding of the current state of play: about what it is being taught in schools and universities, attitudes towards it, and about what might be done to help support quantitative teaching and learning; all backed-up by a systematic review of university courses and resources. Peer networking events were held at the Royal Geographical Society (with IBG)’s annual conference, and with the Higher Education Academy to look at maths and stats skills in the transition from schools to university.

Our findings do not discount what some regard as the diminished importance given to quantitative methods (in human geography especially) nor the frustration and sometimes lack of support given to those who teach them. Yet, we find no evidence that quantitative methods have been abandoned: the typical

Of 580 geography students in year 2 or above

46% disagreed

that their geography course had too much focus on maths and statistics.

Only 17% agreed

student in geography will still encounter them in their course and training. It may well be that what is taught is insufficiently demanding (mathematically) to meet more advanced research needs and to compete with the levels of quantitative methods training found in some other countries. It may also be somewhat backward-looking, firmly embedded in the paradigm of small-sample, frequentist statistical methods that are not necessarily appropriate to effective analysis, visualization and handling of so-called ‘big data’ where the idea of random sampling is spurious and traditional notions of statistical significance have little meaning. Nevertheless, we believe that pessimistic readings of the current situation do not tell the whole story. Rather, we find reason to believe that geography is in a position of relative strength with the opportunity to build on existing good practice and to strengthen the quantitative methods training it provides to pupils and students.

We recommend that the Benchmark Statement for the discipline be updated to reflect this, and that ways be found to work with schools, data agencies and examination authorities to embed interaction with data within the GCSE and A-level curricula in more imaginative ways - using creative media such as Hans Rosling’s GapMinder tools, or open data sites such as The Guardian Data Store. Forming a community of practitioners that bridges between schools, universities and employers, and which offers peer support and training, will be to the long term benefit of the discipline. The British Academy has begun scoping work for a graduate level qualification in quantitative methods, acting as a ‘kite mark’ for study in the social sciences. We watch this development with interest.

To be clear: we are not arguing for the dominance of quantitative methods at the expense of qualitative or any other approaches. Our discipline has been, and should remain, a broad church that gains from a diverse body of members. Nevertheless, the current climate is one in which concerns have been raised (and demonstrated) about the under-capacity in quantitative methods within UK social science. Geography retains capacity. Now is the time to build on it.

About the data

The data for this report were collected over the period of autumn 2012 to spring 2013. They are from four surveys: a survey of 97 teachers, distributed online and at Royal Geographical Society (RGS-IBG) professional development events; a survey of 800 students from 48 UK Higher Education institutions, distributed online and at RGS-IBG Ambassador and other events; a survey of 72 university instructors (lecturers) at 42 institutions, distributed online and at RGS-IBG events; and a telephone survey of 16 heads of teaching. The data do not constitute a random sample and their analysis is limited to simple descriptive statistics.* This cannot resolve any biases in the data; for example, amongst the teachers, 45% taught in an independent (fee-

charging) school. To help ensure our findings are accurate we also have undertaken reviews of university courses (e.g. their entry requirements) and of the current GCSE and A-level geography curricula, and participated in peer events to understand the views of teachers and lecturers. Specific results remain sample-dependent, of course; however, it is the bigger picture we are interested in here. We are confident that our surveys combine to give a rounded portrayal of what is happening in schools and universities in regard to quantitative methods and their teaching.

*For the student survey, because the number of responses varies by institution, the reported values are weighted ($w = 1/n$ where n is the number of respondents for that institution)

What we mean by quantitative methods

For our survey of teachers, quantitative methods were defined to “broadly mean data collection, analysis and presentation” (which includes GIS and Remote Sensing). For our surveys of university instructors and heads of teaching it was also broad: “it includes, but is not limited to, data manipulation; presentation and analysis; visualisation; mapping; cartography; statistics; GIS; modelling etc.” For the student survey the focus was more on maths and statistical skills.

In retrospect, it may be that quantitative methods is too narrow a phrase, implying a

focus on particular techniques, especially statistical tests and GIS. A better descriptor would be quantitative skills and processes, which we take to include the learning of computer and data handling skills to process, combine, analyse and present data, and also the ability to think critically (not merely negatively) about quantitative approaches - to take informed and professional judgements regarding statistical analysis and modelling. It is this wider view that we have in mind as the target for learning amongst geography students.

Summary of the report

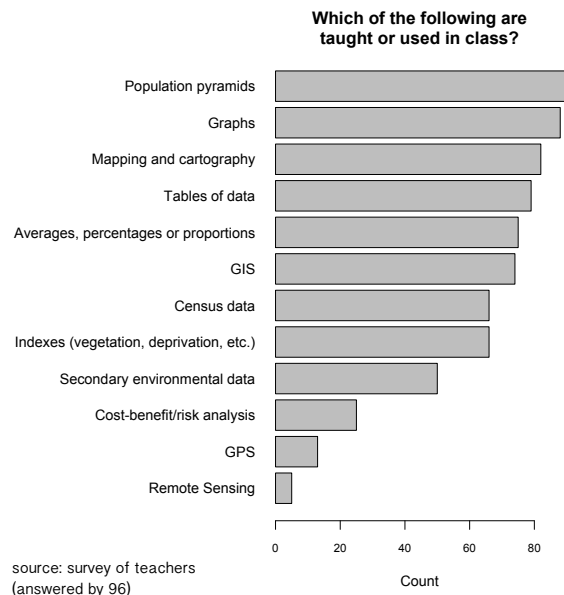
- (1) A student in geography can expect to be taught and to use quantitative methods at school and at university. Typically these methods will include GIS, descriptive statistics and inferential statistics.
- (2) However, teachers report that quantitative methods are not well integrated in the geography curricula. At university, standalone quantitative courses can give the impression that quantitative methods are not part of the substantive themes of human geography in particular.
- (3) Teachers appear less confident in their knowledge of quantitative methods - especially geospatial technologies - and find it less enjoyable to teach. There is opportunity to develop resources providing imaginative and engaging uses of data that are well linked to the geography curricula.
- (4) In universities, quantitative methods appear to be taught by instructors with the expertise to do so, who enjoy their teaching and feel it is valued. Specific training in quantitative methods teaching is rare, including for postgraduate teaching assistants.
- (5) Almost half of the university students surveyed said they struggle with quantitative methods. These tend to be the students who did not study maths after GCSE. Nevertheless, a clear majority of students see the value of quantitative methods for their future career.
- (6) We believe the Benchmark Statement for geography should be revised to be more specific about the role of quantitative methods and the importance of numeracy in all areas of the discipline.
- (7) We are optimistic about the capacity of the discipline to respond to the call for greater quantitative training. However, we are not complacent. Attention should be given to whether the levels and ambition of quantitative methods teaching in geography are sufficiently high when compared to some other disciplines and countries.

Making the connections: schools

A report published by the Royal Statistical Society and the Actuarial Profession (*The Future of Statistics in our Schools and Colleges*; Porkess, 2012), records how geography makes use of the data presentation techniques taught in GCSE maths, uses controlled assessment based on fieldwork to display and interpret data, and teaches statistical techniques such as Spearman's rank correlation. Fieldwork means that statistics are taught in an applied setting and the key processes of data analysis, problem analysis, data collection and data presentation are kept together (more so than in maths).

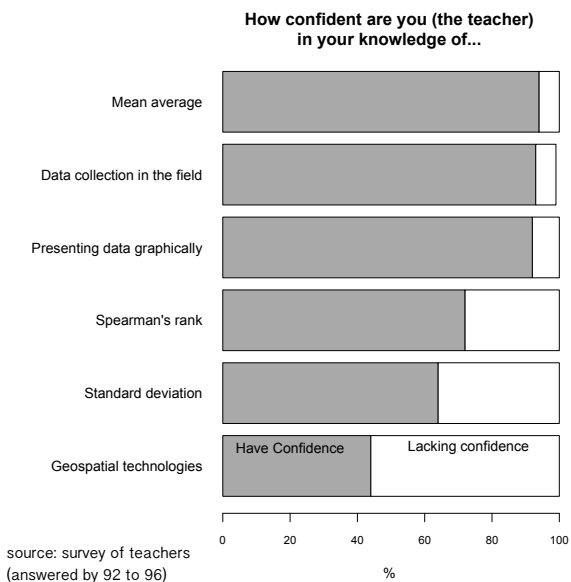
In their book for AS/A-level Geography (*Investigative & Research Skills & Techniques*) Redfern & Skinner (2008) include: types of sampling; questionnaires and scales to measure attitudes; types of survey and sources of secondary data; arithmetic and logarithmic graphs, and Lorenz curves; pie charts, bar graphs, proportional symbols, histograms, scatter plots and other graphs; types of mapping, including flow mapping; measures of central tendency and of dispersion; location quotients; Spearman's rank correlation, the chi-squared test, and the Mann Whitney U test; nearest neighbour statistics; and GIS. The exact exposure to quantitative methods depends on the syllabus specification followed - AQA (with the largest market share in 2011) appears more traditional in its use of statistical approaches whereas Edexcel (second largest) has a focus on the interpretation of data. Nevertheless, it is clear that a student of geography will encounter quantitative methods both at GCSE and at A-level.

In our survey of teachers the most commonly taught statistic was the mean (92%), followed by: Spearman's rank (83%); median average (74%); mode (68%); standard deviation (57%); interquartile range (51%); chi-squared test (51%) and the Mann Whitney U test (46%). Of the respondents, 93% agreed that quantitative methods are an important skill for students to learn, although only 48% agreed it was something they enjoyed teaching. Worse, only 37% agreed that quantitative methods are well integrated within the geography curriculum (88% agreed that putting quantitative methods in a geographical context helps students to understand them better). Maths anxiety is a problem: 63% of teachers agreed that their students get anxious when asked to work with data; 58% identified the mathematical confidence and ability of students as an important challenge



limiting effective teaching of quantitative methods; 42% identified their own (lack of) confidence; and 41% a lack of resources. The majority, 62%, were against the idea of requiring a specific maths qualification to proceed into A-level geography. In regard to GIS, Google Earth was the most popular tool, used by 96% of respondents.

Our findings support what we know of the geography curricula and what the Royal Statistical report suggested: geography is an active user of applied quantitative methods. The challenges are to embed those methods effectively in the curricula so they are not taught as an end in themselves, to be more creative in the use of new media for engaging interaction with data, and to provide effective resources and training for teachers, especially to support confidence in using geospatial technologies.



Making the connections: universities

Broadly, the respondents to our student survey split into two groups: the 42% who either agreed or strongly agreed that they struggle with quantitative methods, and the 41% who disagreed or strongly disagreed (the remainder were neutral). Of the strugglers, only 7% studied maths or statistics after GCSE, 83% are anxious when having to use statistics in geography, and 54% said that their experience of quantitative methods at school had prepared them poorly for university. Of the non-strugglers, 43% studied maths or statistics after GCSE, only 5% are anxious, and 67% said school had prepared them well. Unsurprisingly, 63% of those who struggled agreed that they did not feel prepared for the level of maths and statistics encountered in the first year of their degree, whereas 83% of those not struggling disagreed.

‘Maths anxiety’ and a lack of confidence with quantitative methods is markedly greater among students who have not studied maths or statistics after GCSE

Taken as a whole, 38% of students agreed that their experience of quantitative methods at school prepared them well (29% disagreed) but that support decreases with year group and so presumably the level of teaching: 43% of year 1 students agreed (17% disagreed); 39% of year 2s agreed (24% disagreed); 31% of year 3s agreed (50% disagreed). Encouragingly, 63% of students agreed that they could easily access quantitative methods support through their university (21% disagreed). The importance of quantitative methods for careers is well understood: only 15% of respondents said knowledge of quantitative methods would hold little or no importance to their career plans.

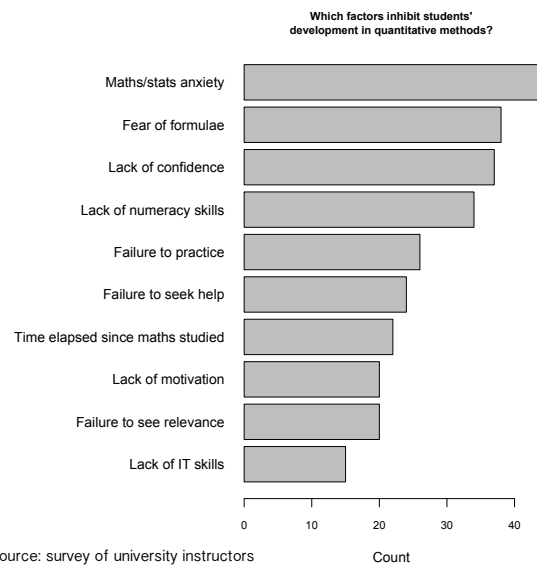
What is being taught and assessed in geography programmes (the instructors’ view; % of respondents)

	Taught	Practised	Assessed
GIS	96%	91%	89%
Descriptive statistics	96%	89%	78%
Inferential statistics	91%	74%	72%
Use of statistical software	88%	88%	73%
Remote Sensing	84%	81%	73%
Methods of visual presentation	84%	74%	65%
Spatial Statistics	59%	59%	50%
Computer Modelling	54%	51%	49%

source: survey of university instructors (answered by 47)

The university instructors have a different view of how well prepared students are in their mathematical and statistical skills: 62% described their students as not very well prepared; a further 12% as not at all prepared. Only 26% of instructors described students as adequately or well prepared. Asked how well students’ expectations match with reality, replies such as this are typical (although not universal): “Poorly - they expect a low maths content”

Instructors’ expectations (or perhaps, more correctly, their experiences) are that students will have a basic level of mathematical, statistical and data handling skills.



source: survey of university instructors (answered by 47)

Only one instructor said that their degree programme places students into different ability streams for quantitative methods teaching; six used diagnostic testing to determine the levels of students' mathematical/statistical knowledge. The most common forms of additional support available for students are drop-in services provided by the university, online resources and in-class support.

Amongst those who responded, the majority of instructors enjoy teaching quantitative methods and felt their work is valued. The most common criteria for allocating staff to teach quantitative methods is expertise (90%) and staff preference (53%). The ‘hot potato’ of passing it to the most recently appointed member of staff until they too can pass it on is, thankfully, rare.

There are notable differences in the assessment of instructors and of students themselves in how well prepared the students are for learning quantitative methods

Results from our survey of heads of teaching complement those from the instructors: the majority of programmes teach descriptive statistics, inferential statistics, methods of visual presentation, computer modelling, spatial statistics, GIS, Remote Sensing and the use of statistical software - although not necessarily to all students. Seven described their BA programme as more qualitatively based than quantitative; six described it as balanced. Seven described their BSc programme as more quantitatively based, five as balanced, and one as

more qualitative. Staff allocations for teaching quantitative methods courses are primarily based on expertise. Evidenced also in the instructors' replies, there is a lack of specific training given to teaching quantitative methods, and this is true for postgraduates that often assist with the teaching.

Specific training to assist the teaching of quantitative methods appears rare, including for postgraduate teaching assistants

Attitudes to quantitative methods (the views of heads of teaching; % of respondents)

	Agree	Disagree	Neutral
Quantitative methods are a fundamentally important part of a Geography degree	92%	8%	0%
The teaching of quantitative methods is valued by my department	77%	8%	15%
Students understand why quantitative methods are included in their degree programme	62%	15%	23%
Quantitative methods concepts and skills are embedded across the degree programme	62%	23%	15%
There is a lack of awareness of the importance of quantitative skills for finding employment or entering further study	39%	39%	23%
My institution places more importance on teaching quantitative methods in physical geography than human geography	25%	75%	0%
Students start their degree programme with realistic expectations about the amount of Mathematics/Statistics involved	23%	62%	15%

source: survey of heads of teaching (answered by 13)

How useful will quantitative methods be to your career plans?

“Not very important because I want to be a social/human geographer”

Turning more specifically to human geography, sentiments like the above are rare in our student survey but not without precedent. In a separate survey of all first-year geographers in a Russell group university, 66% strongly agreed that learning quantitative methods is important to understand research, 50% strongly agreed it is important for their education, 45% that it is important for understanding and contributing to scientific debate, and 43% to get a job. In contrast, 20% strongly agreed that learning quantitative methods is important for social debate - a percentage that is still high (only 20% actually disagreed) but notably lower than for the other statements. This difference hints at a concern, picked-up by some of the instructors and heads of teaching, and the subject of discussion in other parts of the social sciences: how to embed quantitative methods within other parts of the (geography) curricula such that they are not taught just as standalone modules but are presented as integral to, say, social, political and economic geography.

For some instructors there is frustration, commenting that “quantitative methods in social science have been sidelined for the last 30 years”, that “many human geographers think it is totally unnecessary/optional for them and resent having to do it”, and that “some of the cultural geographers in my department ultimately are dismissive of quantitative methods because they see it as positivist.” Such feelings are due, in part, to the ‘science wars’ that took place across the social sciences, with bitter skirmishes evident in some books and journals, including those published within geography. It has been suggested to us that quantitative human geographers have been slow to engage in philosophical debate (to demonstrate, for example, that the label of positivism has been mis-applied). This may well be true although there are exceptions.

It is important to be forward-looking. We are living in more pragmatic times, with greater recognition of the value of quantitative methods and their contribution to empirical social science. It is inevitable that different university departments will offer differing degrees of specialism in differing research methods, not all of which will be quantitative. We return, below, to the question of what the minimum standard - the benchmark - should be.

Making the connections: employers

A 2011 report by the Advisory Committee on Mathematics Education (Mathematical Needs: Mathematics in the workplace and in Higher Education) comments on interviews undertaken in universities and across sectors of employment. It states, “we need more young people to know more mathematics and to be confident in using it” (p.1) Two reasons are given.

First, “the quantitative demands of almost all university courses are increasing” - it cites history as a discipline that now recognises the value of statistics.

Second, “in the workforce there is a steady shift away from manual and low-skill jobs towards those requiring higher levels of management expertise and problem-solving skills, many of which are mathematical in nature.”

Although we would argue that there are good, intellectual reasons for learning quantitative methods to enable geographical learning and

enquiry, the added advantage that these methods also offer a transferable skill that is important in the workplace is undeniable.

For this report we did not survey employers about the value they place on quantitative methods (we did not wish to duplicate existing research, see: <http://www.rgs.org/OurWork/Study+Geography/Careers/Employability.htm>). Instead, we worked with representatives of the environmental, insurance, financial, local government, humanitarian and other sectors to produce a series of short videos and accompanying case studies showing how and why they use quantitative methods in their work. We hope these will be useful to students - in schools and universities - who are considering the merits of learning quantitative methods with geography.

They are available to view and to download at the website www.quantile.info (under Case Studies)



We have produced a series of videos and case studies showing how quantitative methods are used in the workplace.

They are available at www.quantile.info

Making the connections: the benchmark statement

Here we provide a brief overview of the benchmark statements for Geography and other selected disciplines, noting where they reference quantitative methods. Recommendations are made for the next benchmark statement. A draft version of those recommendations was prepared by the authors; feedback was then solicited from peers before a further consultation took place inviting comments from subscribers to the RGS-IBG Quantitative Methods and GIScience Research Groups mailing lists. The final recommendations as they appear below reflect the body of opinion from those research communities.

Current benchmark statements

The specific reference to quantitative methods is in Section 3.12:

3.12 [A]ll geographers should be conversant with a substantial range of analytical and

observational strategies, including most or all of the following: social survey and interviewing methods; geographical field research; laboratory-based analysis (both scientific and computational); quantitative analysis; qualitative analysis; and modelling strategies. Students should also be familiar with the developing technology associated with these strategies, such as computer packages for statistical and qualitative analysis, specialist computing and remote sensing.

The equivalent reference in Earth Sciences, Environmental Sciences and Environmental Studies (2007) is similar although adding more specific consideration of sampling:

3.10 The graduate key skills that should be developed in ES3 degree programmes are:

appreciating issues of sample selection, accuracy, precision and uncertainty during

collection, recording and analysis of data in the field and laboratory; preparing, processing, interpreting and presenting data, using appropriate qualitative and quantitative techniques and packages including geographic information systems; solving numerical problems using computer and non-computer based techniques; and using the internet critically as a means of communication and a source of information.

The benchmark statement for Sociology (2007) advocates “an understanding of a range of qualitative and quantitative research strategies and methods”, “the ability to identify a range of qualitative and quantitative research strategies and methods and to comment on their relative advantages and disadvantages”, and the opportunity to develop transferable skills in “statistical and other quantitative techniques.”

Most interestingly, the benchmark statement for Economics (2007) has an explicit statement about numeracy:

5.5 It is worth emphasising further the issue of numeracy. Economists frequently use information that is presented in some numerical form, and students should be appropriately trained in this regard. The raw data are often in tables, the processed data as a graph, an average, a correlation and so on. Numeracy, statistical and computing skills are necessary to handle this sort of information. Presentation skills are needed to communicate such quantitative information in usable ways, and particularly to give critical and coherent summary representations of data that cannot be readily absorbed raw. As well as formal manipulative and presentation skills required to deal with statistical data, economists learn not to be misled by numbers. They question whether the numbers represent what they claim (e.g. unemployment, price indices), they understand statistical significance (e.g. the margin of error in a poll or survey) and they are aware of at least some of the difficulties in sampling a population. In addition, with some understanding of econometrics, they recognise that conclusions drawn from data might be ambiguous.

Recommendations for the revised statement for geography

Objectives

- (1) To be more explicit about the types of quantitative methods a geography student should have experience of.
- (2) To balance a baseline of (frequentist) statistics with recognition of the growing importance of quantitative methods appropriate to the analysis and visualization of ‘big’ and of complex data, including methods for data manipulation, modelling and scientific computing.
- (3) To include a statement on numeracy.

With reference to the current statement, the revised version might read:

(3.12) All geographers should be conversant with a range of analytical and observational strategies, including most of the following: social survey and interviewing methods; geographical field research; laboratory-based analysis (both scientific and computational); data manipulation; quantitative analysis; qualitative analysis; and modelling strategies. They should be taught both the principles and the application of these methods and techniques.

A fuller statement of what is meant by quantitative analysis might then follow, as, usefully, would a statement about numeracy:

Quantitative analysis involves the presentation, interpretation and communication of numerically

encoded data, typically through the use of statistical, cartographic, visualization and modelling software. Data may be collected by the student or involve the use of secondary data sets such as those provided by a national census. A student in geography typically will encounter courses on the principles of research design, methods of analysing and presenting data, on inferential, relational and spatial statistics, on building numerical models (models of social processes and/or physically-based numerical models), and about geospatial technologies such as GIS and Remote Sensing. In an age of ‘big data’, crowd-sourced data, complex data and open source data, new methods for gathering, presenting and extracting knowledge from such data may be taught.

Suggested statement on numeracy

Geographers frequently use information that is presented in some numerical form. The raw data are often in tabular form; the processed data as a graph, as a table of elementary statistics, as an output from a model, or as a map.

Numerical skills are necessary to handle this sort of information. Presentation skills are needed to communicate quantitative information in usable ways. Students should be able to move appropriately between counts, rates, standardised and index values, and be familiar with more advanced forms of statistical analysis

and model building. They should have the ability to judge what is an appropriate spatial (and temporal) scale for the purpose of the analysis.

Geographers should learn not to misapply data. They should question whether the numbers represent what they claim. They should understand the principles of determining statistical significance and of forming confidence intervals, and be aware of some of the difficulties in sampling a population. They should appreciate the limitations of classical statistical approaches when applied to very large datasets or those that violate assumptions of independence. They should be aware of the problems of generalising from data with no clearly defined population.

Conclusion

At the time of writing, the Nuffield Foundation, ESRC and HEFCE have announced conditional awards made to 15 universities, giving total funding of £19 million to what will be known as Q-Step Centres with the aim to promote a step-change in the quantitative skills of UK social science undergraduates. The initiative is part of a wider cultural change that recognises that quantitative social science has been allowed to lapse for too long. The issue of quantitative training is not limited to the social sciences, however. It is a salient issue in the sciences and the humanities too.

We believe geography is well positioned to support and to benefit from the increased emphasis given to quantitative methods. The evidence we have collected for this report suggests that the teaching of quantitative methods remains a fundamental part of a geographer's training both at school and at university. Geography draws strength from its links across the sciences, social sciences and the humanities, and most likely this has helped to preserve the importance given to quantitative methods when it has declined in other disciplines.

However, we are not complacent: we suspect that the levels of quantitative methods training - perhaps especially in human geography and outside some specific departments - are not sufficiently high. In commenting on the recommendations for the revised benchmark statement, one senior and internationally-respected academic recommended the teaching of "calculus, matrix algebra, and perhaps partial differential equations." No doubt some will balk

Geographers should recognise that conclusions drawn from data can be ambiguous and may be affected by issues such as the modifiable areal unit problem, ecological fallacy and issues of spatial (and temporal) dependence. They should be capable of critically evaluating quantitative material published within academic literature and elsewhere, and able to balance critique with knowledge of the importance of numerical analysis and empiricist methodologies for social and scientific debate. Their quantitative education should be aimed at enabling them to take informed and professional judgements regarding statistical analysis and modelling whilst appreciative of other approaches.

at this but he raises an important point: these are the sorts of mathematical knowledge that are required to compete internationally. It is sobering to look through books such as 'A Mathematics Course for Political and Social Research' (Moore and Siegel, 2013), 'Essential Mathematics for Political and Social Research' (Gill, 2006) or any of the books introducing maths for economists and to see what is demanded.

An important consideration is what actually we mean by quantitative methods in geography: does it simply reduce to 19th/early 20th century statistical methods with a measure of GIS thrown in? Or does the age of 'big data', complex data, longitudinal data, crowdsourcing and the development of numerical models of global processes demand other types of skills and knowledges?

Opinions will vary. However, we found agreement that students need to be excited by data and what you can do with it, with this excitement beginning at school and continuing into universities. Formulae may be necessary but they rarely inspire. Effective use of data to provide dynamic visualisations that are of relevance to, social or environmental geography (for example), do.

The challenge, and opportunity, is to demonstrate the relevance of quantitative methods in practice - not just for career goals but for all sorts of geographical scholarship - inspiring the next generation of geographers to acquire a strong quantitative skill base. Improved connections with better signalling of the needs of schools, universities and employers, can only help.