RESEARCH ARTICLE

Geographers Count: A Report on Quantitative Methods in Geography

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Abstract

This report is drawn from a project funded to better support the teachers of quantitative methods in UK social science. In it we identify the types of quantitative methods taught in the geography curricula for UK schools and universities, and discuss attitudes towards those methods amongst students and teachers. We argue that geography has benefitted from its position at the intersection of the sciences, social sciences and humanities, retaining a quantitative component. Consequently, levels of basic numeracy and data handling have remained relatively high, leaving the discipline well placed to respond to the call for greater quantitative training within the social sciences in the UK. However, we also suspect that the typical levels of quantitative training in university human geography courses are not sufficiently high to compete on the international stage. As the title suggests, our report is focused on geography. However we raise issues germane to other disciplines including what actually we mean by quantitative methods, what should be taught in a twenty-first century curriculum, how to meaningfully embed those methods in the substantive themes and teaching of a discipline, and whether more should be expected as a minimum standard of quantitative competence than the existing Quality Assurance Agency benchmarks require.

Keywords: Geography, teaching, quantitative methods, curriculum, numeracy

Introduction

Within the UK, there has been widespread concern at the low and declining levels of quantitative training provided for students in many of the social sciences (economics and psychology generally excepted). Students, it is argued, are generally "adept at critique [. . .] in the précis and juxtaposition of arguments, and the rhetoric of essay writing". However,

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doi:10.11120/elss.2014.00035

"they are often poor at handling evidence systematically, and especially poorly trained in dealing with *quantitative* evidence" (MacInnes 2012, emphasis added).

Inadequate quantitative methods training both leads to and follows from low levels of numeracy and statistical literacy, creating a negative spiral of decline. What is at stake matters well beyond whether a student can use a particular statistical test or not. The decline threatens methodological pluralism. It spills over into other areas of research training, leaving students lacking in the principles of research design, in forming answerable questions and in reaching conclusions through the rigorous scrutiny of empirical evidence – skills that are of importance to qualitative as well as quantitative approaches. It inhibits students' ability to critique the misuse of statistics in policy or in the media or to defend a counter view. An inability to 'do numbers' restricts them from entering whole swathes of social research, including measuring inequality, looking at changing patterns of social and ethnic segregation, investigating whether social mobility has stalled in the UK, or determining who are the victims of austerity cuts and welfare changes, to give just four examples with the sort of moral dimension that can appeal to a student.

Geography is not immune to such trends. According to the recent International Benchmarking Review, UK human geography ranks first in the world. However, the same review also identifies a reduced training and expertise in quantitative methods, with a "surprising underinvestment" in Geographical Information Systems (GIS). The consequences of these reductions are reported to be: "(1) a decline in quantitative literacy, (2) a small recruitment base for advanced quantitative methods [including at the postgraduate level], (3) a lower return to investment in longitudinal and space-referenced data because many lack necessary data-analytic skills, (4) a lack of necessary competence among students for entering the professional workplace where such skills are in demand, and (5) a growing methodological divide between human and physical geography" (ESRC 2013, p16).

The problems are not confined to human geography. Some commentators have identified a skills gap between the (lack of) field, analytical and numerical skills geography students learn in schools and what instructors (perhaps, especially, physical geography instructors) expect of those students in universities (Mathison & Woodward 2013). However, whereas the need for calculation and quantification is largely taken for granted in physical geography with its connections to the physical and environmental sciences, the same cannot be said of human geography which reaches into the humanities and social sciences, too, where greater suspicion of quantitative methodologies lie. Some have bemoaned the mischaracterisation and lack of space given to quantitative approaches in textbook introductions to human geography for undergraduates (Johnston 2006, Johnston *et al.* 2014). Nevertheless, much of what has been reported is anecdotal or based on specific examples. What has been missing, and what this report aims to provide, is a more systematic review of the types of quantitative methods taught in the geography curricula for UK schools and universities, attitudes towards them amongst students and teachers, and of prospects for the future.

The findings presented here draw upon a report published by the Royal Geographical Society (with IBG) and presented to the geographical community at the Royal Geographical Society Annual Conference in London in 2013 (Harris *et al.* 2013). It was funded by the British Academy, Economic and Social Research Council (ESRC) and by the Higher Education Funding Council for England (HEFCE) as part of their researchers' development initiative for quantitative social science. Both here, and in the initial report, we draw on the results of four surveys, undertaken over the period of autumn 2012 to spring 2013. These were a survey of 97 schoolteachers of geography, a survey of 800 geography students from 48 UK higher education institutions, a survey of 72 university instructors (lecturers) of

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doi:10.11120/elss.2014.00035

geography at 42 institutions, and a survey of 16 Heads of Teaching in university geography departments. 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). Each of these surveys was conducted online and also distributed at RGS-IBG professional events, with the exception of the Heads of Teaching survey, which was undertaken by telephone.

The data do not constitute a random sample and their analysis is limited to simple descriptive statistics. That limitation does not resolve any biases in the data of which the most notable is that 45% of the teachers surveyed taught in an independent (fee-charging) school. Therefore, both to help ensure our findings are accurate and to understand better the views of teachers and lecturers, we also undertook online reviews of university courses and of the current GSCE and A-level Geography curricula, as well as participating in peer events organised by the Higher Education Academy (HEA), by the school examination agencies and by ourselves. Taken together, the evidence – both quantitative and qualitative – forms what we believe to be an accurate representation of the 'bigger picture'. It gives a rounded portrayal of what is happening in schools and universities in regard to quantitative methods and to their teaching in geography.

This report proceeds as follows. First we introduce the disciplinary context and, in particular, the research context in which quantitative methods have flourished but subsequently waned in human geography. We then use the findings from our surveys to describe what is happening in schools and universities before concluding with a closing summary and consideration of the benchmark statement for geography.

The disciplinary context

Geography is an unusual subject in the ways it bridges between physical science, social science and the humanities. Its status as a part-STEM subject groups it with science, technology, engineering and mathematics. Degree-level geography students go into a wide range of jobs including retail, business, finance, government and public service, conservation and environment, IT, health, media, teaching and research (Solem *et al.* 2008, Geographical 2010). The recent White Paper on higher education funding reforms (BIS 2011) listed geography as one of eight disciplines that offer a wide range of career opportunities with one of the lowest unemployment rates amongst graduates (Porkess 2013).

A relatively recent decline in the number of pupils taking the subject at school appears to have reversed with the subject being included (with history) in the English Baccalaureate – not, itself, a qualification as such but more a 'league table' measure applied to recognise where pupils have secured a C grade or better across what the Department for Education describes as "a core of academic subjects" – these being English, mathematics, history or geography, the sciences and a language (DfE 2013a).

Currently there are about 29 000 students taking a degree in geography, of which more than 20 000 are full-time undergraduates. In recent years almost one third of undergraduates have gone on to further study across a range of disciplines. Instigating a change in the quality of quantitative methods teaching within geography will diffuse into the social sciences and into industrial sectors more widely.

Geography has a long tradition of quantitative methods research and teaching. It led the development of spatial statistical approaches and process modelling in the late 1960s and early 1970s, and was initially quick to adopt, develop and apply GIS technologies, especially in the late 1980s and early 1990s. More recently, the discipline has also embraced earth observation technologies and numerical modelling as techniques for studying the planet's

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doi:10.11120/elss.2014.00035

surface and subsurface. However, it has also been wary of such technologies and their potential for surveillance, militarism, and for being a return to narrow quantification and naïve empiricism within the discipline.

The 'quantitative revolution' of the 1960s and 1970s represented a period when economic theory and appeal to physical principles such as laws of gravity were used to model and to explain social processes and the patterns of, for instance, migration, trade or development generated by those processes. Such approaches fell out of favour from a period beginning in the 1970s following criticisms alleging their uncritical adoption of ideas and theories supporting hegemonic capitalist practices, power structures and inequalities, their lack of sensitivity to issues of gender, sexuality, disability (and so forth), and because of a general focus on the aggregate and presumed rational behaviour as opposed to individual whim, emotion, trust, fear and other human traits.

Suspicion about the philosophical underpinnings of what came to be described as spatial science remains (Doel 2000, Cloke *et al.* 2004, Johnston 2006, Kitchin 2006). Nevertheless, it is now better recognised as a mistake to associate quantitative methods only with positivism, to miss their use in critical social analysis or to suggest they are necessarily antithetical to qualitative approaches (Poon 2003, Poon 2005, Kwan & Knigge 2006, Barnes 2009, Wyly 2009, Jones 2010, Harris & Jarvis 2011).

Although it is hard to deny that human geography has witnessed a quantitative de-skilling – most obviously in regard to the mathematical demands of what is taught in universities – it would be a mistake to regard the situation as merely bleak. In fact, geography has a strong track record of peer support, knowledge sharing and supporting pedagogic goals through institutions such as the Geographical Association, the Royal Geographical Society, the CTI Centre for Geography, Geology and Meteorology, contributions to the JISC-funded Teaching and Learning Technology programme, the Higher Education Academy Subject Centre for Geography, Earth and Environmental Sciences, and Spatial Literacy in Teaching (SPLINT), a HEFCE-funded Centre for Excellence in Teaching and Learning of which four of the current authors were directors, managers or researchers. The discipline always has retained a strong desire to teach quantitative methods effectively (see, inter alia, Unwin & Maguire 1990, Unwin 1997). There are a number of university departments that teach quantitative methods, including micro simulation, GIS and GI Science, spatial analysis or multilevel modelling to a very high and world-leading standard.

Furthermore, geography remains characterised by a belief that there are common patterns of behaviour, the understanding of which is critical to appreciating society. It is this perspective that feeds so effectively into evidence-based public policy (including crime or disease mapping) and also to private sector strategies (e.g. locational decision-making supported by large firms such as Esri or Experian).

From our perspective, the situation is one where a proliferation of research methods, cultures and interests has afforded a creativity and imagination leading to the high ranking of human geography in the International Benchmarking (see Introduction, above). We would not want to return to a time when the discipline is dominated and straightjacketed by (literally) formulaic thinking. At the same time, given the renaissance in quantitative social science in, for example, North America (Harvard founded its Institute for Quantitative Social Science in 2004) there is a risk that geography in the UK will fall behind, producing students who simply do not have the training to work at the research frontiers. The issue – which we return to below – is not whether geography is a numerate discipline. To the most part, it is. The issue is whether the levels of quantitative training in schools and then universities are sufficient for the demands of employers, cutting-edge research in quantitative social science or even to engage in informed critique of the way that numbers

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and data are (mis-) used in policy, science and society (Dilnot & Blastland 2008, Fioramonti 2014).

These are problems that appear to be generic across many of the UK social sciences (ESRC *et al.* 2010, Hodgen *et al.* 2010, MacInnes 2010, ACME 2011). For example, the 2007 International Benchmarking Review of UK Politics and International Studies was generally positive but reported a weakness in formal, statistical modelling (ESRC 2007, cited by Adeney & Carey 2009). In sociology, Williams *et al.* (2004) report from a national survey of British sociology undergraduates that "students view quantitative research negatively" and that "this may be reinforced by staff attitudes" (p28). In a later report, the authors (Williams *et al.* 2008) offer greater nuance: "the overall impression is that whilst most students are not wholly comfortable with quantitative methods, they do see a need for them in sociology" (p1012). The issue, they suggest, is not so much the students' lack of numeracy. What they lack is interest – and that places a responsibility not only on the learners but also on the instructors, on how and what they teach.

The call for greater and better quantitative training in the UK is now the focus of considerable investment from multiple agencies including the ESRC, the British Academy, HEFCE, the Higher Education Funding Council for Wales, the Scottish Funding Council, the Nuffield Foundation and the HEA. Perhaps the most visible beneficiaries of this investment are the new Q-Step Centres, charged with leading a step change in the quality and level of quantitative skills learning (Nuffield Foundation 2013). Of the fifteen initial centres, four involved geography.

The situation within schools

The investment in university-level quantitative skills training is very welcome and long overdue. However, it can only form part of a wider strategy of raising standards because students' views of quantitative methods are first formed by what they learn and experience in their school classrooms. At the very least, it is here that issues of maths and statistical anxiety emerge, where opportunities for numeracy, data handling and interpretation can be provided, and where the development of statistical know-how can be creatively incorporated into the very heart of the curriculum (and not taught as a tedious and equation-driven adjunct that both teacher and pupil would prefer to avoid).

There has been much concern about raising standards of mathematical attainment in the UK. The UK ranked 26th in the most recent Programme for International Student Assessment results (Coughlan 2013) and there are now consultations upon a new 16 to 18 core maths qualification for students not otherwise taking mathematics in those years (DfE 2013b). However, it is not clear that maths skills per se are the problem since "learning the kind of quantitative methods that we need to teach students at undergraduate level requires only very basic mathematical skills" (MacInnes 2012, p15). The issue is more about applied data handling than pure maths: a confidence, willingness and flair in combining data with statistical thinking to pose and to answer questions of relevance to the discipline of geography. Indeed, an entirely maths focused approach may prove counter-productive where for many users quantitative methods are better taught in context, not in the abstract (Watson 2000, Keylock & Dorling 2004, Smith 2004). Raising mathematical proficiency may help improve quantitative social science but it is what happens in the disciplines themselves that has the potential to really impact on the students' belief, or otherwise, that quantitative approaches are relevant and useful. In short, it is not more mathematical teaching that is required per se. It is subject-based experience of posing and answering questions using a quantitative toolkit that includes data collection, use of secondary data, forms of data visualisation, applied statistical analysis and, for geography, use of geospatial technologies.

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Geography is viewed favourably in a report on the future of statistics in UK schools and colleges (Porkess 2012) because it teaches statistics in context, especially through fieldwork. As a consequence, it keeps the parts of the 'statistics cycle' together from posing a question of relevance to the discipline, through collecting (or finding) data about it, to undertaking the analysis and thence drawing conclusions. Ironically, those parts are often separated in the teaching of statistics within maths, which hinders students' appreciation of why what they are learning is useful.

In a further report looking at statistics opportunities across A-level subjects, Porkess (2013) reports that the current AS- and A-level specifications in geography require learners to become adept in the use and application of skills and new technologies but without an explicit identification of the quantitative (nor qualitative) skills that should be required of all geography courses. In their book for AS/A-level Geography, Redfern and Skinner (2008) include the skills listed in Table 1. Taken as whole, they are impressive and wide-ranging. However, the actual 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. Even so, it is clear that a student of geography will encounter quantitative methods at GCSE, at AS- and at A-level (the key stages of 15/16–18 year old examination). Whether this helps statistical understanding is a moot point. Crawley (2007) wryly describes chi-square as something taught to geographers at school and misunderstood thereafter! That is unfair (but a good joke); nevertheless, in meetings with teachers, some expressed their discomfort of teaching statistics that they neither like nor understand but have to do because the curriculum requires it.

Table 1 Quantitative skills present in the geography AS-/A-level curricula according to Redfern & Skinner (2008).

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
Geographical Information Systems (GIS)

In our survey of teachers, the most commonly taught statistic was the mean (92%), followed by: Spearman's rank (83%); median (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

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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. With respect to GIS, Google Earth was the most popular tool, used by 96% of respondents, although confidence in teaching with geospatial technologies is relatively low (it is the quantitative method that the teachers had least knowledge about).

Encouragingly, the proposed AS- and A-level subject content for geography (from September 2015) specifically requires that the assessment of quantitative skills in geography AS- and A-level must comprise 10% of the whole assessment (DfE 2013c). That percentage is, perhaps, a little low (it is proposed to be 15–20% in economics) but in sociology, for example, there is no minimum (DfE 2013d). The annex to the current consultation document says that in order to be able to develop their skills, knowledge and understanding in geography, learners need to have acquired competence in the quantitative skills shown in Table 2. This appears to us to be a very thorough and desirable list of practical quantitative skills.

Table 2 Quantitative skills proposed for the new AS- and A-Level subject content for geography (Department for Education 2013c).

Calculating and interpreting percentages, fractions, proportions and ratios
Using map coordinates
Recognising the different types of variable and scales of measurement
Using and interpreting a variety of data sets, primary and secondary
Understanding the strengths and limitations of sampling methods
Choosing appropriate graphical and cartographical methods of presentation
Using GIS to map and to present geographical data
Interpreting and drawing conclusions from data presented in graphical, tabular and cartographic form
Calculating and interpreting mean, mode and median, and measures of dispersion and concentration
Recognising positive and negative correlation and interpreting the strength of correlations
Using scatter plots and line of best fit
Analysing geographical relationships by generating appropriate hypotheses and using appropriate statistical tests
Interpreting the results of statistical tests including their statistical significance

The challenge is to encourage interest in quantitative methods amongst pupils (and often amongst their teachers too), to embed the 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. A positive development is that geography, unique amongst the A-level subjects, may be permitted a coursework element of assessment instead of just end of year, unseen exams. Fieldwork provides the "opportunity to become immersed in problems, and [to] form and test hypothesises. Typically such work requires data to be collected, analysed and interpreted within a cycle of activity [a context] [. . .] The introduction of coursework would provide an opportunity for students' fieldwork, and its associated quantitative and statistical methods, to contribute to

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their final grades at A level" (Porkess 2013, p95). In other words, learning *and doing* quantitative methods, would count, and that is to be encouraged.

The situation within universities

DeCesare (2007) warns that the presumption of 'statistics anxiety' amongst social science students often lacks empirical evidence and can become a self-fulfilling prophecy. Even so, 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.

It would seem that studying A-level Maths (or equivalent) does impart a confidence that readies the student for university. However, that confidence may be misplaced as there is a disjuncture between how well prepared students think they are and how their instructors rate the students' 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 are that students will have a basic level of mathematical and statistical skills but with variability within a group (since mathematics at A-level rarely is a pre-requisite for a geography degree). To re-iterate, it is too simple to say that what is required is simply more mathematical training. At least as important is applied experience of using quantitative, data-handling skills within a disciplinary context.

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 with the level and demands of the 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.

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 Bachelor of Arts (BA) programme as more qualitatively based than quantitative; six described it as balanced. Seven described their Bachelor of Science or Social Science (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. Drawing on Williams *et al.*'s (2008) findings of what is taught to sociology students and how difficult they find those methods (Table 3), it seems that many if not most geography students are learning both the 'easier' and 'harder' techniques, and will have done so beginning at school, continuing into university.

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Table 3 How sociology students rated the difficulty of various quantitative methods and the number that were taught them in Williams *et al.* (2008) survey (source: Williams *et al.* 2008).

		Easy	Hard	N[I]
Group A	Bar charts, pie charts	94.6	5.4	626
	Mean, median, mode	92.0	8.0	636
	Sampling	84.0	16.0	583
	Frequencies	79.9	20.1	556
	Histograms, scattergrams	79.8	20.2	526
Group B	Correlation	73.2	26.8	570
	Hypothesis testing	63.8	36.2	486
	Standard deviation	59.3	40.7	543
Group C	Chi Square	46.6	53.4	335
	Pearson's r	45.5	54.5	231
	Cramer's V	45.3	54.7	139
	Z tests	44.7	55.3	150
	Spearman's rho	42.5	57.5	200
	Regression	40.1	59.9	227

N is the total number of students who said they had studied the subject.
Group A is "intuitively understandable topics requiring little arithmetic skills and largely visual" (Williams et al. 2008, p1015).
Group B is "topics that require greater conceptualization or logic and perhaps more confidence with number" (ibid).
Group C is "topics that form a more conventional core of basic statistics [. . .] requiring more grasp of number and the internal logic of statistical reasoning" (ibid).

Turning more specifically to human geography, sentiments like the following are rare but not without precedent: "How useful will quantitative methods be to your career plans? Not very because I want to be a social/human geographer." 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. It seems that students have a pragmatic appreciation of the value of studying quantitative methods but are less persuaded of their relevance to their disciplinary studies – again, a similar finding to that of Williams *et al.* (2008).

The reduction hints at a concern, picked-up by some of the instructors and Heads of Teaching, the subject of discussion in other parts of the social sciences, and the same issue we have raised for the school curricula: how meaningfully 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 or economic geography. This is not an easy undertaking, in part because of the reduced number of university instructors in human geography with quantitative methods training (at the higher levels of those methods, at least) but also because the learning of quantitative methods is cumulative: inference follows on from description and explanation thereafter; general liner modelling follows from multivariate ordinary least squares regression, which follows from simple bivariate regressions, correlations and scatter plots; and so forth. It is not as simple as introducing a number, tables or charts into the occasional lecture and presuming it is enough to teach quantitative methods. It is not. It may usefully demonstrate the relevance

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of the methods and help reinforce the students' learning but would also fall short of the levels of quantitative training that are now required to have a meaningful engagement with the research frontiers in quantitative social science.

One area of current review is the QAA benchmark statement for Geography (QAA 2007c). Our view is that the current statement, which sets out what should be expected in regard to the learning outcomes of a geography degree, is too vague on the sorts of quantitative skills that should be required of students – it is a 'soft touch' statement that, although no less demanding that comparable subjects, in actuality requires no more quantitative knowledge of students than the sorts of learning they would have undertaken in primary school:

> [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 (ES3) (QAA 2007a) is similar although adding more specific consideration of sampling:

> 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 (QAA 2007d) advocates "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 (QAA 2007b) has an explicit statement about numeracy:

> 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.

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> In addition, with some understanding of econometrics, they recognise that conclusions drawn from data might be ambiguous.

In consultation with the wider quantitative and GIS communities, we offered three recommendations for geography's revised statement:

1. To be more explicit about the types of quantitative methods a geography student should have experience of.
2. To balance a baseline of more traditional statistical approaches with recognition of the growing importance of quantitative methods appropriate to the analysis and visualisation of 'big' and of complex data, including methods for data manipulation, modelling and scientific computing.
3. To include a statement on numeracy and about the expectations of what to be numerate in geography requires.

At the time of writing, proposals for the revised benchmark statement are ongoing although it seems unlikely that the demands on quantitative methods learning will be raised as greatly as we might like. Nevertheless, we hope they will be strengthened, with a statement of the following sort at least:

> Geographers should have skills in the presentation, interpretation and communication of numeric data. There will be variation in the methodologies taught in different programmes; however, a student will typically encounter courses on the principles of research design, methods of analysing and presenting data, the retrieval and manipulation of large data sets, on inferential and relational statistics, and about geospatial technologies such as digital cartography, GIS and remote sensing.

Conclusions

Geography benefits from its position at the intersection between the sciences, social sciences and humanities. Although human geography has experienced the same critiques and antipathy to quantitative methods as other parts of the social sciences, the discipline as a whole has also never lost its scientific and therefore quantitative component.

The evidence we have collected from our surveys, from our curricula reviews, and from our participation in peer events lead us to believe geography is well positioned to support and to benefit from an increased emphasis given to quantitative methods. Although some instructors expressed frustration, commenting that "quantitative methods in social science have been side-lined for the last 30 years", that "many human geographers think it is totally unnecessary 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", we do not find any strong evidence that quantitative methods have been marginalised from human geography in the ways that some suppose.

Admittedly, our surveys did not focus specifically on human geography but on the discipline more generally. The consequence may be to inflate the amount of quantitative training some students appear to receive, although, as we have emphasised, training begins at school where students will do a mixture of physical and human geography, and continues at university where many programmes will offer a core year of all aspects of geography before offering specialism in later years. Our findings do not deny a de-skilling since the quantitative 'heyday' of the 1960s and 1970s. Nor is it to suggest that quantitative methods necessarily achieve an equal billing in core human geography in all university departments – a problem exacerbated by standalone methods courses, and perhaps also

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by the logic of marketisation, competition and specialism in particular areas of human geography (a specialism that also permits some departments to train students to very high quantitative standards). However, it remains the case that quantitative methods are a fundamental part of a geographer's training both at school and at university. Indeed, they may even have achieved an almost protected status in the disciplinary canon (Cresswell 2013). Geography draws strength from its links with the sciences and most likely this has helped to preserve the importance given to quantitative methods when it has declined in other disciplines.

As such, a student in geography can expect to be taught and to use quantitative methods at school and at university, with this knowledge and experience offering a potential pathway to employment that is appreciated by students. Typically these methods will include Geographical Information Systems (GIS), descriptive statistics and inferential statistics. However, there is a problem of how embedded these methods are into the substantive themes and topics that characterise the discipline.

In schools, teachers report that quantitative methods are not well integrated in the geography curricula. A reason could be the skill set and training of teachers. Teachers appear less confident in their knowledge of quantitative methods, especially geospatial technologies (GIS), finding them less enjoyable to teach. There is therefore opportunity for the academic community to work with teachers and with the exam agencies to develop resources providing imaginative and engaging uses of data that are well linked to the geography curricula. However, this is not necessarily straightforward in an environment that privileges research over teaching, especially as a metric for career progression.

In universities, quantitative methods appear to be taught by instructors with the expertise to do so and who enjoy their teaching. We find little evidence of the metaphoric 'hot potato' where the teaching of these research methods are thrown to the most junior (and powerless) member of staff until they, in turn, are in a position to pass it on. Even so, specific training in quantitative methods teaching is rare, especially for postgraduate teaching assistants who will often be the ones supporting the students in applied practical work. The near universal mantra of research-led teaching assumes that through research knowledge and expertise comes proficiency in teaching and pedagogy. It may, but like the quantitative methods being taught, the reasoning might not add-up. Effective teaching matters because 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.

We do not wish to be complacent. We suspect that not enough human geographers are trained to the higher levels required to advance postgraduate research in quantitative social science. An important consideration is what actually we mean by quantitative methods in geography: does it simply reduce to nineteenth-/early twentieth-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 knowledge – data harvesting and computing programming skills, for example, and knowledge of Bayesian perspectives? (Graham & Shelton 2013, Ruppert 2013, Brunsdon 2014). Moreover, is it enough to focus on the attraction of applied data analysis (applied teaching) or should more geography programmes include core, and harder, mathematical training in its own right: calculus, matrix algebra, and perhaps partial differential equations, as one senior and internationally respected academic suggested to us. Do human geographers (and other social scientists) aspire to be users of statistical methods and numerical models or should they be trained to be actively involved in their development?

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Our conclusions are therefore mixed. On the one hand, there is little evidence that quantitative methods have been extensively marginalised within geography, with basic levels of numeracy and data handling relatively high. On the other, we are less confident that levels of more advanced quantitative methods training – particularly in human geography, and outside some specific departments – are sufficiently high when viewed on the international stage. It is sobering to look through books such as *A Mathematics Course for Political and Social Research* (Moore & 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 required. We believe that the current benchmark statement for Geography, published by the Quality Assurance Agency for Higher Education and setting out expectations about the standard of a degree, lacks ambition (though no more so than comparable disciplines intersecting with or based in the social sciences) (QAA 2007c). We see opportunities for students to have better (and more interesting) exposure to quantitative methods, and to geospatial technologies, as part of the revised A-level curriculum.

At the time of writing, the British Academy is scoping a national degree level qualification in quantitative skills in social science (British Academy 2013). What is important for us to emphasise is that quantitative skills are not just about maths and statistics, although they may well be important. They are also about graphical design and visualisation, programming, scripting and replication, field and lab skills (Mathison & Woodward 2013), as well as understanding social critiques of the limits of numerical thinking, as for example in concerns about school league tables (Foley & Goldstein 2012) or measures of ethnic segregation (Peach 2009). Moreover, it is important that students are exposed to other types of learning and approaches, too, including those that are qualitative. Creating well-rounded social science students, in geography as in other disciplines, is the key to improving their employability and to reinvigorating the social sciences. Focusing on quantitative skills training is an important part of the equation but is not a panacea.

Acknowledgments

We acknowledge, with thanks, the British Academy, ESRC and HEFCE for funding this research, the work of the Royal Geographical Society (with IBG) in supporting it, and all those who gave their time to undertake surveys or participate in peer events. Particular thanks are due to Katharine Fitzpatrick who worked as a researcher on the project. The views expressed are those of the authors.

References

Adeney, K. and Carey, S. (2009) Contextualising the teaching of statistics in political sciences. *Politics* **29** (3), 193–200.

Advisory Committee on Mathematics Education (ACME) (2011) *Mathematical needs in the workplace and in higher education*. London: ACME.

Barnes, T.J. (2009) 'Not only... but also': quantitative and critical geography. *Professional Geography* **61** (3), 292–300.

British Academy (2013) Graduate QS qualification: scoping a national degree level qualification in quantitative skills in social science. Available at http://www.britac.ac.uk/policy/QS_Graduate_Qualification.cfm (accessed 27 February 2014).

Brunsdon, C. (2014) Spatial science – looking outward. *Dialogues in Human Geography*. In press.

ELiSS, Vol 6, Issue 2 (July 2014)
doi:10.11120/elss.2014.00035

Cloke, P., Cook, I., Crang, P., Goodwin, M., Painter, J. and Philo, C. (2004) *Practising human geography*. London: Sage.

Coughlan, S. (2013) Pisa tests: UK stagnates as Shanghai tops league table. *BBC News Online*, December 3 2013. Available at http://www.bbc.co.uk/news/education-25187997 (accessed 06 December 2013).

Crawley, M.J. (2007) *The R book*. Chichester: John Wiley & Sons.

Cresswell, T. (2013) *Geographical thought: a critical introduction*. Chichester: John Wiley & Sons.

DeCesare, M. (2007) "Statistics anxiety" among sociology majors: a first diagnostic and some treatment options. *Teaching Sociology* **35**, 360–367.

Department for Business, Innovation and Skills (BIS) (2011) *Higher education white paper – students at the heart of the system*. London: BIS.

Department for Education (2013a) English Baccalaureate: information for schools. Available at http://www.education.gov.uk/schools/teachingandlearning/qualifications/englishbac/a0075975/the-english-baccalaureate (accessed 18 December 2013).

Department for Education (2013b) New maths qualifications to boost numbers studying maths to age 18. Available at https://www.gov.uk/government/news/new-maths-qualifications-to-boost-numbers-studying-maths-to-age-18 (accessed 06 December 2013).

Department for Education (2013c) Proposed GCE AS and A Level. Subject content for geography. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/252938/Geography_subject_content.pdf (accessed 05 December 2013).

Department for Education (2013d) Proposed GCE AS and A Level. Subject content for sociology. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/252942/Sociology_subject_content.pdf (accessed 05 December 5 2013).

Dilnot, A. and Blastland, M. (2008) *The tiger that isn't: seeing through a world of numbers*. London: Profile Books.

Doel, M.A. (2000) 1a. Qualified quantitative geography. *Environment and Planning D*, **19** (5), 555–572.

ESRC (2007) *International benchmarking review of UK politics and international studies*. Swindon: ESRC. Available at http://www.esrc.ac.uk/_images/International%20benchmarking%20review%20-%20Politics%20and%20International%20studies_tcm8-4554.pdf (accessed 27 May 2014).

ESRC (2013) *International benchmarking review of UK human geography*. Swindon: ESRC. Available at http://www.esrc.ac.uk/research/evaluation-impact/research-evaluation/international-benchmarking/uk-human-geography.aspx (accessed 27 May 2014).

ESRC, HEFCE, HEFCW (2010) *National strategy for building a world class social science research base in quantitative methods*. Swindon: ESRC.

Fioramonti, L. (2014) *How numbers rule the world: the use and abuse of statistics in global politics*. London: Zed Books.

Foley, B. and Goldstein, H. (2012) *Measuring success: league tables in the public sector*. London: British Academy. Available at https://www.britac.ac.uk/policy/Measuring-success.cfm (accessed 27 February 2014).

Geographical (2010) *Business leaders recommend geography*. Available at http://www.geographical.co.uk/Magazine/Worldwatch/Business_leaders_rec_geog_-_Nov_10.html (accessed 19 December 2013).

ELiSS, Vol 6, Issue 2 (July 2014)
doi:10.11120/elss.2014.00035

Gill, J. (2006) *Essential mathematics for political and social research*. Cambridge: Cambridge University Press.

Graham, M. and Shelton, T. (2013) Geography and the future of big data, big data and the future of geography. *Dialogues in Human Geography* **3** (3), 255–261.

Harris, R. and Jarvis, C. (2011) *Statistics for geography and environmental science*. Harlow: Pearson.

Harris, R., Fitzpatrick, K., Souch, C., Brunsdon, C., Jarvis, C., Keylock, C., Orford, S., Singleton, A. and Tate, N. (2013) *Quantitative methods in geography making the connections between schools, universities and employers*. London: Royal Geographical Society (with IBG). Available at http://www.researchgate.net/publication/256191493_Quantitative_Methods_in_Geography_Making_the_Connections_between_Schools_Universities_and_Employers (accessed 26 February 2014).

Hodgen, J., Pepper, D., Sturman, L. and Ruddock, G. (2010) *Is the UK an outlier? An international comparison of upper secondary mathematics education*. London: Nuffield Foundation.

Johnston, R. (2006) The politics of changing human geography's agenda: textbooks and the representation of increasing diversity. *Transactions of the Institute of British Geographers* **31** (3), 286–303.

Johnston, R., Harris, R., Jones, K., Manley, D., Sabel, C. and Wang, W. (2014) Spatial science and quantitative analysis in geographical curricula. *Dialogues in Human Geography* **4** (1), 3–25.

Jones, K. (2010) The practice of quantitative methods. In *Theory and Methods in Social Research* (eds. B. Somekh and C. Lewin), pp201–211. London: SAGE Publications.

Keylock, C.J. and Dorling, D. (2004) What kind of quantitative methods for what kind of geography? *Area* **36** (4), 358–366.

Kitchin, R. (2006) Positivistic geographies and spatial science. In *Approaches to Human Geography* (eds. S. Aitken and G. Valentine), pp 20–30. London: Sage.

Kwan, M. and Knigge, L. (2006) Theme issue: qualitative research and GIS. *Environment and Planning A* **38** (11), 1999–2074.

MacInnes, J. (2010) Proposals to support and improve the teaching of quantitative research methods at undergraduate level in the UK. Final report to ESRC.

MacInnes, J. (2012) Quantitative methods teaching in UK higher education: the state of the field and how it might be improved. Paper presented at the Social Sciences teaching and learning summit: Teaching research methods, June 2012. Available at http://www.heacademy.ac.uk/resources/detail/events/SS_Summit_2012_MacInnes (accessed 27 May 2014).

Mathison, S. and Woodward, J. (2013) Mind the skills gap. *Planet* **27** (2), 36–38.

Moore, W.H. and Siegel, D.A. (2013) *A mathematics course for political and social research*. Princeton, NJ: Princeton University Press.

Nuffield Foundation (2013) Q-Step Centres. Available at http://www.nuffieldfoundation.org/q-step-centres (accessed 26 February 2014).

Peach, C. (2009) Slippery segregation: discovering or manufacturing ghettos? *Journal of Ethnic and Migration Studies* **35** (9), 1381–1395.

Poon, J. (2003) Quantitative methods: producing quantitative methods narratives. *Progress in Human Geography* **27** (6), 753–762.

ELiSS, Vol 6, Issue 2 (July 2014)
doi:10.11120/elss.2014.00035

Poon, J. (2005) Quantitative methods: not positively positivist. *Progress in Human Geography* **29** (6), 766–722.

Porkess, R. (2012) *The future of statistics in our schools and colleges*. London: Royal Statistical Society.

Porkess, R. (2013) *A world full of data. Statistics opportunities across A-level subjects*. London: Royal Statistical Society/The Institute and Faculty of Actuaries.

Quality Assurance Agency (2007a) Subject benchmark statement: earth sciences, environmental sciences and environmental studies. Available at http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/EarthSciences.pdf (accessed 18 May 2014).

Quality Assurance Agency (2007b) Subject benchmark statement: economics. Available at http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/economics.pdf (accessed 18 May 2014).

Quality Assurance Agency (2007c) Subject benchmark statement: geography. Available at http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/geography.pdf (accessed 19 December 2013).

Quality Assurance Agency (2007d) Subject benchmark statement: sociology. Available at http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/Sociology07.pdf (accessed 18 May 2014).

Redfern, D. and Skinner, M. (2008) *AS/A-level geography: investigative & research skills & techniques*. Abingdon: Philip Allan Updates.

Ruppert, E. (2013) Rethinking empirical social sciences. *Dialogues in Human Geography* **3** (3), 268–273.

Smith, A.F.M. (2004). *Making mathematics count*. London: HMSO.

Solem, M., Cheung, I. and Schlemper, M.B. (2008) Skills in professional geography: an assessment of workforce needs and expectations. *The Professional Geographer* **60** (3), 356–73.

Unwin, D.J. (1997) Mathematics in university geography. *Geography* **82** (1), 75–78.

Unwin, D.J. and Maguire, D.J. (1990) Developing the effective use of information technology in teaching and learning in geography: the computers in teaching initiative centre for geography. *Journal of Geography in Higher Education* **14** (1), 77–82.

Watson, J. (2000) Statistics in context. *The Mathematics Teacher* **93** (1), 54–58.

Williams, M., Collett, T. and Rice, R. (2004) *Baseline study of quantitative methods in British sociology*. University of Plymouth: School of Sociology, Politics and Law. Available at http://www.ccsr.ac.uk/methods/festival2004/programme/Sat/am/MSTheatre/documents/Williams_000.pdf (accessed 27 May 2014).

Williams, M., Payne, G., Hodgkinson, L. and Poade, D. (2008) Does British sociology count?: Sociology students' attitudes toward quantitative methods. *Sociology* **42** (5), 1003–1021.

Wyly, E.K. (2009) Strategic positivism. *The Professional Geographer* **61** (3), 1–13.

ELiSS, Vol 6, Issue 2 (July 2014) doi:10.11120/elss.2014.00035