The changing nature of GIS and the provision of formal GIS education in the UK: a case study

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Abstract

The arrival of the term Geographical Information System (GIS) in the 1960s soon created a demand for training and education in the use of this specialist hardware and software. Initially the main focus was on training people to use GIS, formal named degree programmes leading to postgraduate and undergraduate qualifications arrived later. This paper explores the changing landscape of UK degree level GIS education drawing on contemporary information from Higher Education Institution websites and a case study of the first single honours degree in GIS. The paper identifies a rise and fall in the number of named undergraduate 'GIS' degrees since the late 1980s sandwiched between the continuation and development of postgraduate qualifications. In parallel with this trend the teaching and learning of GIS skills has emerged as a core component of undergraduate degree programmes with 'Geography' in their title and in national school and degree level benchmarking statements for the discipline.

Keywords: geographical information system and science; formal GIS education; undergraduate GIS degree.

1. Introduction

The arrival of the Canada Land and Geographic Information System (Tomlinson, 1962) not only started a new, hybrid form of information technology, which continues to develop and evolve after more than 50 years, but also set in motion two important trends: the need to educate and train people in its use and its assimilation into many and diverse walks of everyday life. Many drivers and pedestrians would now be quite literally lost when travelling without unknowingly employing the spatial analytic tool of network analysis in a navigation system connected to global positioning satellites. Current developments in respect of driverless vehicles take the concept of automated machine awareness of geographical space to a new level [Benenson et al., 2008], presenting a situation in which vehicles not people follow instructions to navigate a route. It is not surprising given such scenarios for future methods of personal transportation that the challenge of defining GIS has taxed educators, researchers and professionals since the term was first coined (examples see, Burrough, 1986: 6; Maguire, 1989: 171; Kraak and Ormeling, 1996: 9; Heywood, Cornelius and Carver, 2006: 19).

The inexorable advance of GIS in our daily lives and the ubiquity of spatial analysis in Internet-based applications used by the general public as well as in desktop computing environments of commercial, public and voluntary organisations emphasise the importance of GIS. Changes in GIS technology and its coupling with Geographical Information Science as a conceptual and theoretical framework for investigating phenomena distributed through geographical space (Goodchild, 1992) have changed formal teaching of GIS at undergraduate and postgraduate levels. However, some of the algorithms embedded in GIS build on spatial analytic techniques that appeared in Geography texts of the 1970s (for example, Haggett, 1972), Starting from the premise that using GIS to map or analyse geospatial data in a desktop or internet environment either with or without knowledge of the underlying technology has become the 'norm', this article is concerned with the changing landscape of formal education in the overarching fields of Geographical Information Systems and Science (GISS). This term embraces cartography, geomatics, photogrammetry, remote sensing, image processing, spatial statistics and cognate fields as well as a range of areas where the associated concepts and techniques are applied, such in geodemographics (geo-marketing), land information systems, environmental modelling and land use (spatial) planning.

There has been a focus in recent research on the teaching of GIS on the definition of what constitutes an all-encompassing curriculum for GIS (Prager and Plewe, 2009; Sinton, 2009) and on the ways of delivering this teaching to groups of students with and without a background in geography (Lloyd, 2001; Read, 2010; Srivastava and Tate, 2012). Previous research has also examined students' perceptions of teaching GIS on modules that form an optional part of undergraduate Geography degree programmes in a sample of six Higher Education Institutions from the pre- and post-1992 universities (see below) (Sememet and Chalkley, 2015). This paper aims to explore the provision of and, by means of a case study, the changing balance between formal postgraduate and undergraduate GIS education in the UK. It relates this review to recent (2014) benchmarking statements in respect of 'A' level and undergraduate Geography that have seen GIS become part of the core subject knowledge and skills (Quality Assurance Agency, 2014; ALCAB, 2014).

2. Changes in British Higher Education and Emergence of GIS Education

The main focus of this paper is on the provision of GIS education in British Higher Education, but first it is helpful to review the main changes in this system occurring over the 50 year period coinciding with the development of GISS. The British Higher Education

system is not straightforward and has undergone considerable change and restructuring over this period, which started with the establishment of 13 new publicly funded universities in the 1960s (Jobbins, 2013). These coincided with publication of the Robbins Report (1963), which amongst other things recommended an expansion of degree level education. This led to 10 colleges of technology that had been established in 1956 becoming universities and a number of local authorities establishing polytechnics, many of which were based on training colleges. The degree programmes offered by the polytechnics were often of a more vocational nature and were validated and conferred through the centralised Council for National Academic Awards (CNAA). The next main stimulus for growth in the sector occurred with the *1992 Education Act*. This enabled the polytechnics to receive their royal charters granting them university status and the formation of universities from other types of institution, some of which were initially linked to existing universities: this expansion during the 1990s and 2000s increased the number of HEIs by 75. The CNAA was abolished in 1993 as these new universities were granted their own degree-awarding powers. Most of these Higher Education Institutions (HEIs) offer undergraduate and postgraduate taught courses and research degrees: some HEIs offer study in a comprehensive spectrum of disciplines and subjects, whereas others concentrate on a more limited range (e.g. Norwich University of the Arts). This simplified outline of the changing HE landscape in the UK was further complicated by the presence of the University of London and University of Wales each with their constituent colleges, which have in many cases now become separate HEIs, and the collegiate system of the Universities of Cambridge and Oxford.

Teaching and learning for students on undergraduate and postgraduate degrees with respect to how to use or apply as distinct from how to engineer or program computer hardware and software is contextualised by a number of factors. These include the overall prevailing ‘state of the art’ of information technology at the time when they are studying, the excitement or trepidation of being introduced to something new and unfamiliar, and the expectations and requirements of potential employers to recruit employees with up-to-date information technology skills. Developmental research in relation to the ongoing re-specification and re-definition of the ‘state of the art’ of GIS in the late 1960s and 1970s took place in universities, public and commercial bodies on both sides of the Atlantic, although the pace of its acceptance, implementation and uptake in the UK and other European countries lagged behind Canada and the USA. The emergence of formal GIS education reflected this pattern with postgraduate programmes developing in a group of North American Universities that were developing technological solutions to the challenges

posed by the desire to enable ‘geospatial computing and visualisation’. These included the Laboratory for Computer Graphics and Spatial Analysis at Harvard University and the Environmental Systems Research Institute (ESRI) in the USA (Cerny, 1972; Dangermond and Smith, 1988) and the University of Edinburgh in Scotland (Aitken and Hotson, 1974).

Formal education in pursuit of a qualification or training for professional development and re-skilling with respect to an emerging technology may reasonably be assumed to reflect the corpus of knowledge corresponding to the ‘state of the art’ of the technology and the procedures required for its assimilation within the operations and working practices of organisations adopting it. A central requirement of many early GIS projects involved the transfer of geospatial data from an analogue, typically paper format into a digital medium by capturing the coordinates and attribute characteristics of terrestrial features. Even in the mid-/late 1980s the practice of accessing previously captured digital geospatial data over the Internet as a standard procedure was still some way in the future for most GIS users outside academia. The capture of data by means of manual digitising and the building of databases that allowed the interrelationships between geospatial features, so apparent when viewed on paper maps, to be represented in a digital medium were therefore key skills to be covered by learners during the early years of GIS.

The mid-1980s was an especially significant time for the development and uptake of Geographical Information) GI technologies in the UK and the emergence of formal GIS education: changes prompted in no small measure by two government commissions of enquiry. The first, *Remote Sensing and Digital Mapping* reported on the UK’s engagement with this increasingly important source of Earth observation data (Department of the Environment, 1983). The second, *Handling of Geographic Information* surveyed the current state of geographic information handling in respect of digital data availability and structures, nature and implementation of GI systems, provision of education and training, research developments, case study applications across the public and public sectors and other matters concerning the emergence of the GI industry (Department of the Environment, 1987). The Commission headed by Lord Chorley took evidence from a large number of organisations and individuals and reached 24 summary conclusions and made 64 detailed recommendations in seven overarching areas aimed at improving the handling of geographic information in the UK. The Education and Training summary conclusion stated “There is [...] a need to increase substantially, at all levels, the provision of trained personnel.” (Department of the Environment, 1987: 2) and articulated nine recommendations for achieving this. This acted as a stimulus for the enhancement of

existing and development of new undergraduate degree level qualifications in GIS as examined in a case study in the following section. In part this arose from recorded evidence of instances of where organisations had embarked on the acquisition of GI data, hardware and software without having adequate regard to the need for personnel with the necessary skills and expertise to implement such technology. The commissioners viewed a nascent landscape of GIS education in Britain and the at least partially unidentified need for personnel with the education, skills and training capable of unleashing the potential of this rapidly evolving technology in the public and private sectors.

3. Changing Provision of GIS Education in the UK

The section examines the changing provision of formal GIS education in the UK overall and uses a case study to explore in some detail how the balance between postgraduate and undergraduate GIS courses reflect evolution of the higher education sector and the nature of GIS itself. The broader scales developments indicated on the left side of Figure 1 provide a context for changes in the overall level of GIS education provision as well as a link to the evolution of GIS courses in the case study institution, Kingston University (see below). At the time of the Chorley Commission a sparse scatter of British universities offered one year postgraduate degree qualifications in GIS, such as the University of Edinburgh and the University of Leicester and less than 10 HEIs had started to include GIS in their undergraduate programmes, although rather more included cartography and digital mapping to some extent. The Chorley Report emphasised that school as well as university level students should be exposed to the new technology as well as professional staff in post in a variety of organisations who were struggling to implement and apply it.

3.1 Changing Context

This section set the scene for examining changes in the provision of GIS education in the UK by discussing three factors that have contributed to a situation whereby the landscape of formal GIS education in the UK has to some extent returned to the one that prevailed in the 1980s when a discrete number of universities offered postgraduate degrees in the field. One of the key differences between then and now is that virtually all undergraduate degrees in Geography and some in cognate disciplines also offer introductory level exposure to GIS for their students, whereas the option of ‘doing a bit of GIS’ was more limited in the 1980s.

The first key factor relates to change in the geographical information (GI) industry, which has evolved and professionalised over the 25 years. There was expansion and diversification in the number of companies working on supplying the sector with GI technology and geospatial data during the 1990s, which resulted in a proliferation in the range of GIS software, peaking at over 200 products. This reflected the changing environment of IT as it moved from central to personal hardware architectures and as operating systems evolved to become more 'user friendly'. However, this expansion was followed by a period of consolidation as company mergers and failures resulted in a more limited range of proprietary software in the marketplace. These changes were paralleled by an almost classical diffusion or uptake of GIS technology in other commercial sectors (e.g. environmental consultancy and retail planning), to public organisations (e.g. Environment Agency and National Health Service), central and local government and even into certain parts of the charitable and voluntary sector. There are now relatively few areas left untouched by the spread of GIS technology either undertaken 'in house' or contracted out to other organisations. Such diffusion would seem to bode well for recruitment to undergraduate degree programmes specialising in GISS, but as we have seen this has not been the case largely because of the ease with which basic geoprocessing and map-making can be achieved without specialised knowledge and skills and the availability of 'cut and pasted' maps on the Internet. During the early years of GIS the specialist software developed in universities often with assistance from government laboratories was "often made available first in the public domain" (Neteler et al., 2012: 124). Such "volunteer projects" (Steiniger and Hunter, 2013: 148) have been perpetuated and formalized recently through the work of the Open Geospatial Consortium (http://www.opengeospatial.org/). The availability of open learning resources and software challenges the need for formal GIS education.

The second key area of change is in respect of students themselves over the 25 years and in particular their experience not only of GIS education but perhaps more significantly of 'geographically enabled' devices before going into higher education. As the Chorley Commission reported teaching of GIS was piecemeal at pre-university level education in the UK in the 1980s, although the signs of its potential importance were already evident in the media, even if only in such modest offerings as satellite images of the Earth and animated maps accompanying television weather forecasts. Even if the term GIS was unfamiliar and ambiguously part of information technology or geography curricula, school and college students could see it as something potentially 'exciting' and 'new' as a course for undergraduate study at university or polytechnic. The intervening years have seen GIS

become part of everyday life for many people and the normality of being connected to the Internet by mobile devices for the latest generations of students raises new issues for those seeking to provide GIS education and training. Teaching GIS in British schools and colleges still faces many challenges despite efforts to promote and facilitate the subject by a number of organisations including the Ordnance Survey, Association for Geographic Information, the Royal Geographical Society (with IBG) and the Geographical Association. These efforts have included such practical help as offering maps, data and software to schools and mentoring and training teachers. The recent revision of the National Curriculum for Geography programmes of study includes “use Geographical Information Systems (GIS) to view, analyse and interpret places and data” (Department for Education, 2013) at Key Stage 3. This raises the prospect that in the near future students will arrive at university with a more advanced GIS skill set than their predecessors. However, the jury is out as to whether this will lead to GIS as an undergraduate degree subject arising like a phoenix from the ashes.

The third key area of change over the last 25 years has been in UK’s tertiary education sector in respect of its institutional structure, the organisation of degree programmes and the funding arrangements. At the start of the period HEIs were universities with their own degree awarding powers or polytechnics that offered degrees from the Council for National Academic Awards. This divide was removed in 1992 when the polytechnics were ‘converted into’ universities and since that time other colleges and institutes of higher education have been granted university status in their own right or passed through a transition to university colleges linked to an established degree awarding university prior to attaining this position themselves. The early postgraduate degrees in GIS were launched by older universities, whereas the pioneers of undergraduate GIS degrees comprised a small group of the new universities (formerly polytechnics or similar) (e.g. Bath Spa, Coventry and East London Universities), although a few older universities (Newcastle University) subsequently followed suit. Modularisation of degree programmes spread through many UK universities from early in the 1990s, replacing the traditional linear structure with its emphasis on end-of-year examinations. Modularisation in universities paralleled similar developments in pre-university education. The GIS core curricula of the NCGIA and RICS (Unwin, 1989) were well suited to a modular course structure enabling different components of the subject to be introduced in stages. Government policy with respect to the payment of fees and maintenance grants to undergraduate students and the management of student numbers have also changed over the 25 years. A GIS undergraduate degree might be regarded as serving a niche market and be perceived as a

more risky subject for study by students who are required to repay loans for fees and maintenance after graduation when compared with essentially ‘free’ higher education in the early 1990s. Recent policy changes have led many universities to scrutinise their portfolio of courses and close those repeatedly failing to attain their target recruitment. However, even at the peak of undergraduate GIS degree provision in the mid-/late 1990s the annual number of students per course was in all likelihood less than current viable target numbers in cognate fields such as Geography.

3.2 GIS Education and its provision

Goodchild (1985) provided a succinct review of the dilemma facing the inclusion GIS in undergraduate courses and, although this centred on his experience of the position in Canada, there were parallels with the landscape of GIS education in the UK at that time. He questioned whether GIS should “be given a place in the accepted philosophical underpinnings or our discipline [Geography], or is it merely a bag of tricks of no significance?” (Goodchild, 1985: 35). In trying to answer this question, he discussed three ‘deeper issues’ that he considered as “fundamental problems in clarifying the role of GIS in the curriculum” (Goodchild, 1985: 35). These were the external rather than internal impetus for its inclusion, the traditional belief that GIS was an advanced (postgraduate) specialisation rather than an undergraduate level subject area and ambiguity over the content and level that might be appropriate arising from the absence of an uncontested definition of GIS. At the time there were relatively few undergraduate programmes in Canada and the USA allowing students to specialise in GIS and none in the UK, although a growing number of were starting to offer elective or optional units in the subject, including some British higher education institutions (HEIs).

The National Center for Geographic Information and Analysis (NCGIA) was established at a similar time in three universities the USA in 1988 (University of California, State University of New York and University of Maine). The NCGIA worked on defining a core curriculum for GIS (Goodchild and Kemp, 1990; Kemp and Goodchild, 1991) and paralleled initiatives in the UK (Abler, 1987). The intention was not to produce a comprehensive GIS textbook, but to provide a fundamental core curriculum that GIS lecturers could dip into and adapt to suit the needs of their own students. In the UK the Royal Institution for Chartered Surveyors (RICS) sponsored the development of a *Curriculum for the Teaching of Geographical Information Systems* (Unwin, 1989). He argued that his curriculum (see Figure 2) offered a unified approach to teaching GIS that

could be adapted to the level required for a particular course. He contrasted this with the NCGIA's Core Curriculum, which "is broken down into three self-contained sections" (Unwin, 1989: 10). In the years following publication of the Chorley Report a number of UK universities set about the process of validating and launching undergraduate degree programmes in GISS with the overall aim of addressing this skills' gap and others continued to process of including GIS in their Geography programmes. However, the 2014 *Geography Benchmark Statement* for undergraduate programmes took this further by stating geographers should be required to know about and understand "... geospatial technologies such as digital cartography, Geographic Information Systems (GIS) and remote sensing." (Quality Assurance Agency, 2014: 9).It took a little longer for GISS and use of remotely sensed imagery (Curran and Wardley, 1985) to become part of the school level curricula despite the almost archetypal example of a GIS in the form of the BBC's Domesday Disk for schools, which was launched in 1986 to celebrate the 900th anniversary of the original Domesday Book (Openshaw, Wymer and Charlton, 1986), being created at the same time that the Chorley commissioners were working. In 2014 the 'A' Level Content Advisory Board (ALCAB) for Geography stated that "Geographical information science is an important part of geography … This area includes geographical information systems, remote sensing and the collection and handling of geo-located data." (ALCAB, 2014: 7)

The *Geography Benchmark Statement* (Quality Assurance Agency, 2014) has undoubtedly contributed to the extent of GIS education in British universities in 2016, especially in those which have recently undergone period review of their programmes. According to the Universities Central Council on Admissions (UCAS, 2016) there are 84 HEIs providing undergraduate degree programmes with Geography in their titles plus another nine with geographical content although Geography is not in their title (UCAS, 2016). UCAS uses codes to distinguish different courses and there are currently 360 named degrees with Geography in their titles from 85 HEIs covering 127 separate course codes. There is considerable variation in the number of degree programmes with Geography in their title per institution up to a maximum of 15 in one case (Table 1). The main codes are F800 and L700 respectively corresponding to 3 year full-time BSc and BA Geography programmes, at least one of which is offered by 61 (72 per cent) of the 85 HEIs. Slightly less than 50 per cent (28) exclusively offered both course codes and 38 per cent one of them with a slight majority of these single offerings being BSc Geography (F800). The complexity of undergraduate Geography provision in British HEIs, with various discipline combinations for joint degrees and standard three year bachelors and four year

integrated masters programmes, making it difficult to summarise the extent of GIS education provided on these courses. The approach adopted here is to identify from the institutions' own websites whether there is a core and/or optional unit or module in GIS in at least one of the named Geography degree programmes; or whether there is use of terms such as GIS skills indicating that even if a dedicated GIS module is not evident then at least some exposure to GIS is being provided, for example through an integrated geographical skills module.

Some of the HEIs' course websites (18) did not provide sufficient details of the course structures or modules to determine whether GIS was part of their programmes and the extent of provision recorded in Figure 3 relates to those HEIs that enabled this information to be determined. Over 70 per cent teach GIS at Level 4 (first year) with the majority of these doing so by means of including the subject within a module that does not have GIS in its title. However, a substantial majority (94 per cent) have at least one core or optional module in their programmes with GIS or a similar term in its title. The results make clear that GIS education has now become a mainstream component of most British undergraduate Geography degrees and the *Geography Benchmark Statement* (Quality Assurance Agency, 2014) makes clear that the development of knowledge and skills in this respect is now regarded as core element of the discipline. However, this was not the case in the late 1980s and the following section examines the creation, launch, development, evolution and closure of the first undergraduate degree in GIS in Europe and the rise and fall of similar degrees over the period.

3.3 Case Study

On 18 September 1989 Kingston Polytechnic (KP) (now Kingston University (KU)) enrolled its inaugural cohort of 35 students onto the first single honours undergraduate BSc Degree in Geographical Information Systems in Europe. The last cohort of eight students on this degree graduated on 23 July 2015 and over nearly 26 years and 24 student cohorts since the first enrolment in excess of 600 graduates were awarded their undergraduate Bachelor of Science (Honours) (BSc Hons.) or Higher National Diploma (HND) in GIS. However, the starting point for Kingston Polytechnic to launch its GIS degree can be found earlier in the 1980s with the award of a PhD to Peter Fisher (Fisher, 1982), who became a lecturer in the institution teaching remote sensing and subsequently a leader in the development of geographical information science. He was succeeded by Tim Wood, who was himself replaced by Seppe Cassettari in 1989, who was responsible for launching the (BSc) GIS

Degree. During the 1980s, reflecting a similar in a small number of other HEIs, Geography degree students in Kingston Polytechnic were taught Cartography, computer mapping and an optional GIS unit was introduced into the third year of the degree programme in 1986 (taken by approximately 50% of students). Ed Parsons, now the Geospatial Technologist of Google, was a Geography graduate of this era, later returning as a lecturer early in the 1990s. SYMAP was used for line printer mapping and a 1981 Census Atlas of Kingston upon Thames Borough was produced using GIMMS (Geographical Information Mapping and Management System).

The nearby Kingston College of Further Education (KCFE) was also teaching Ordinary and Higher National Certificate courses that included Cartography, Photogrammetry and Surveying in particular for members of the Ministry of Defence's Mapping and Charting Establishment, Feltham. Collaboration between KP and KCFE resulted in the validation of the BSc (Honours) Degree in GIS with the stated aim "to enable students to acquire knowledge, skills and expertise in GIS, integrated with mapping technology for the purposes of spatial data management" (Kingston Polytechnic, 1989: 1). The underlying philosophy of the course enabled students to acquire knowledge, skills and expertise in GIS and to understand when, why and how it could be applied. The course focused on four themes: information collection methods, data analysis and computing, information presentation and communication, and environmental information, and (see Figure 4). It was seen as important that students should not only be taught the technical skills necessary for using GIS, but also be capable of understanding the underlying geographical processes, hence the inclusion of 'environmental information' units (modules) that were shared with other degree programmes. Students followed a set of core and option units that included a requirement take environmental information (Geography) each year. Most degree programmes in the British HE system historically had a linear form of delivery meaning that the main assessment events occurred at the end of the second and more importantly the third year in the form of 'final' examinations, which contrasts with the modular form in which a fixed number credit weighted modules are studies each year (usually 8 or 4) and assessment events in these in years 2 and 3 contribute typically with a differentiated weighting towards the final degree class. There was an undercurrent of from linear to modular forms of delivery in the late 1980s and 1990s with the consequence that the units in these themes in the validated linear degree were designed such that they could be restructured into a modular degree. It was also formulated in such a way that an accompanying Business and Technology Education Council (BTEC) in GIS could be

introduced in 1991 with scope for successful diplomates transferring onto and completing the BSc (Hons.) degree.

The introduction of the Science Modular Degree Scheme in 1990 converted a system of 10 units per year into an eight module structure with each worth 15 credits and quinquennial revalidation up to 2000s allowed further changes to be made as GI technology, applications and practice changed and teaching staff arrived and departed. These changes included the introduction of programming, geovisualisation, internet GIS, open source GIS modules and the deletion and/or transfer of curriculum content (e.g. surveying and photogrammetry mutated into laser scanning and were incorporated into remote sensing, and cartography transformed into geovisualisation). The initial group of core GIS academic staff (three in KP and five at KCFE) expanded and changed over the years. The sets of figures relating to numbers of graduates and diplomates from the different GIS courses should be treated as estimates for the reasons given in the notes to Figure 5. Although annual fluctuations are evident throughout the period, there was a generally rising trend until the late 1990s, a time when a small group of UK HEIs introduced undergraduate GIS courses and KU added joint honours GIS degree routes in 1999. An MSc in Applied GIS was added in 2003, which later transformed into an MSc in GISS.

A succession of changes was made to other degree programmes during the 25 period that reflected the growing importance of acquiring GIS skills as core for graduates from Geography and other cognate degrees, which was becoming evident across the HE sector as a whole. The original third year GIS option for Geography students was converted into an introductory core GIS module for second year Geography and Geography Joint Honours programmes and added as a co-taught third year option to the Environmental Science degree in 1998. New applied GIS third year option modules (Geodemographic Analysis; GIS and Health; and Crime Patterns and Environment) were introduced in 2000s for students on the BSc in GIS, Geography and other degree programmes. Wider diffusion of GIS occurred in 2007 when a new Digital Earth module was made a core component of all first year undergraduate degrees, which coincided with removal of core GIS module from year 2 Geography degree and as year 3 option for Environmental Science. Modules on the BSc (Hons.) GIS Degree were preserved as exclusive to this programme in order to emphasise its specialist nature and to avoid any lessening of content that might result from accommodating other groups: exceptionally the Land Use Planning module, created for the GIS Degree, was later opened up to other courses.

The reduction in student recruitment to the undergraduate degree was a central factor in the decision to close the BSc programme with the last cohort of students enrolled in September 2012. The inclusion of GIS and remote sensing continues on a range of undergraduate programmes. At a course level Kingston University's emphasis is now on its MSc in Geographical Information Systems and Science taught both on site and via distance learning, which sits alongside some 20 HEIs offering postgraduate qualifications in the field. During the course of the period that Kingston University offered its BSc GIS degree eight other HEIs followed suit to provide single or joint honours undergraduate degrees with GIS or similar terms in their titles. These include Coventry University, Newcastle University, University of Greenwich and the University of Portsmouth. Few such specialist GIS degrees remain, with the University of Brighton offering *Geography with Geoinformatics,* Liverpool Hope University's *Geography and Information Technology*, Newcastle University's *Geographic Information Science* and Swansea University's *Geography and Geo-Informatics* as the main offerings.

4. Conclusion

This paper has reviewed the rise and fall of single honours GIS degrees in the UK using a case study approach. During the 25 year period since 1989 some eight British universities that have launched undergraduate degrees specialising in GISS, although slightly different names may have been applied reflecting their individual emphases. Nevertheless, collectively they can all be seen as seeking to address the shortage of personnel with education and training in GIS identified by the Chorley Report (Department of the Environment, 1987). The landscape of GIS education in the UK includes over 20 universities offering postgraduate qualifications compared with five at the start, extensive undergraduate on named Geography degree programmes and a limited number of dedicated named undergraduate GIS programmes. Postgraduate course seek to satisfy the still growing need to supply an employment market with graduates having the skills and knowledge required to develop these tools for everyone and to apply GIS technologies in an increasingly diverse range of applications. The rise and fall of the demand for first degree graduates in GISS provides a salutary lesson for those institutions seeking to identify degree courses catering for niche markets.

Three factors were discussed as providing the context for this changing provision of GIS education: the mature and professionalised nature of the Geographical Information industry; the greater familiarity of students with information technology in their everyday

lives and education before university; and the new structure and differential financing of degree level study in the constituent countries of the UK. Parallels are have been made between the spread of quantitative statistical analysis in geographical education during the 1960s and the incorporation of GIS during the 1990s/2000s. Taylor (1990: 212) asserted that GIS represented "a most naïve empiricism" that would diminish "after the initial technological flush." However, there is at least one significant difference between these trends, namely that the creation and use of tools based on statistical testing and modelling has not become part of the public's information handling repertoire, whereas millions and more likely billions of the world's population use GIS-based tools on their mobile phones, tablets and other devices on a daily basis. The presence of GIS education in British undergraduate degrees with Geography in their title and inclusion of the subjects as a core element in school 'A' level and undergraduate Geography benchmarking confirms its importance at the present time. The pattern of GIS education distributed across the substantial majority of HEIs offering named Geography undergraduate degree programmes in conjunction specialist postgraduate level courses that has emerged from the contextual changes over the past 25 year has established a level of provision seemingly meeting the current needs of employers.

References

Abler, R.F. 1987 The national science foundation national center for geographic information and analysis. *International Journal of Geographical Information Systems,* 1(4) 303–326.

Aitken, W. and Hotson, J.McG. 1974 Computing for geographers and environmental scientists. *International Journal of Mathematical Education in Science and Technology*, 5(3-4): 489-500.

'A' Level Content Advisory Board 2014 *Report of the ALCAB Panel on Geography*. Available online (accessed 25/11/16): https://alevelcontent.files.wordpress.com/2014/07/alcab-report-of-panel-on-geography-july-2014.pdf

Benenson, R., Petti, S., Fraichard, T. and Parent, M. 2008 Towards driverless vehicles. *International Journal of Vehicle Autonomous Systems*, 6(1-2): 2-23.

Burrough, P.A. 1986 *Principles of Geographical Information Systems for Land Resources Assessment*. Oxford: Clarendon Press.

Cerny, J. 1972 Use of the SYMAP computer mapping program. *Journal of Geography*, 71(3) 167-174.

Curran, P. and Wardley, N. 1985 Remote sensing in secondary school Geography: the place of Landsat MSS. *Geography*, 70(3): 237-240.

Dangermond, J. and Smith, L.K. 1988 Geographic Information Systems and the revolution in cartography: the nature of the role played by a commercial organization. *The American Cartographer*, 15(3): 301-310.

Department for Education 2013 *National Curriculum in England: Geography Programmes of Study*. Statutory Guidance. Available online (accessed 05/10/15): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239087/SECONDARY_national_curriculum_-_Geography.pdf.

Department of the Environment 1983 *Remote Sensing and Digital Mapping*. Report of the House of Lords Select Committee on Science and Technology, HMSO.

Department of the Environment 1987 *Handling of Geographic Information*. Report of the Commission of Enquiry Lords Select Committee on Science and Technology, HMSO.

DiBiase, D., DeMers, M., Johnson, A. Kemp, K., Taylor Luck, A., Plewe, B. and Wentz, E. 2006 *Geographic Information Science and Technology Body of Knowledge*. First edition. Association of American Geographers and the University Consortium for Geographic Information Science.

Fisher, P. 1982 *Plateau gravels of the western part of the London Basin*. PhD CNAA, Kingston Polytechnic (now Kingston University).

Goodchild, M.F. 1985 Geographic Information Systems in undergraduate geography: a contemporary dilemma. *Operational Geographer*, 8: 34-38.

Goodchild, M.F. 1992 Geographical Information Science. *International Journal of Geographical Information Systems*, 6(1): 31-45.

Goodchild, M.F. and K.K. Kemp, (eds.) 1990 NCGIA *Core Curriculum in GIS. National Center for Geographic Information and Analysis*, University of California, Santa Barbara CA.

Haggett, P. 1972 *Geography: A Modern Synthesis*. Harper Row: London.

Heywood, I., Cornelius, S. and Carver, S. 2006 *An Introduction to Geographical Information Systems* (3rd edn). Harlow: Pearson International.

Jobbins, D. 2013 UK higher education since Robbins – a timeline. *University World News*, 294. Available online (accessed 25/11/16): http://www.universityworldnews.com/article.php?story=20131028123008296

Kemp, K.K. and Goodchild, M.F. 1991 Developing a curriculum in Geographic Information Systems: the National Center for Geographic Information and Analysis Core Curriculum Project. *Journal of Geography in Higher Education*, 15(2): 123-134.

Kingston Polytechnic 1989 *BSc Honours Degree in Geographical Information Systems: Course Documentation*. Kingston Polytechnic in collaboration with Kingston College of Further Education.

Kraak, M. J. and Ormeling, F. J. 1996 *Cartography: Visualisation of Spatial Data*. Harlow: Longman.

Lloyd, W.J. 2001 Integrating GIS into the undergraduate learning environment. *Journal of Geography*, 100, 158–163.

Maguire, D.J. 1989 *Computers in Geography*. Longman: Harlow.

Meremet, M.S., Chalkley, B. 2015 Student perspectives on the teaching of geographical information systems, *Journal of Geography in Higher Education*, 39 (1): 18-36.

Neteler, M., Bowman, M.H., Landa, M. and Metz, M. 2012 GRASS GIS: A multi-purpose open source GIS. *Environmental Modelling and Software*, 31: 124-130.

Prager, S.D. and Plewe, B. 2009 Assessment and evaluation of GIScience curriculum using the geographic information science and technology body of knowledge. *Journal of Geography in Higher Education*, 33(S1), 46–69.

Quality Assurance Agency. 2014 *Subject Benchmark Statement: Geography*. UK Quality Code for Higher Education. Available online (accessed 25/11/16): http://www.qaa.ac.uk/en/Publications/Documents/SBS-geography-14.pdf

Raper, J., Rhind, D. and Shepherd, J. 1992 *Postcodes: the New Geography*. Longman: Harlow.

Read, J.M. 2010 Teaching introductory geographic information systems through problem-based learning and public scholarship. *Journal of Geography in Higher Education*, 34, 379–399.

Robbins Report 1963 *Higher Education*. Report of the Committee appointed by the Prime Minister under the Chairmanship of Lord Robbins. London: Her Majesty's Stationery Office.

Sinton, D.S. 2009 Roles for GIS within higher education. *Journal of Geography in Higher Education*, 33(S1), 7–16.

Srivastava, S.K. and Tait, C. 2012 An activity-based learning approach for key geographical information systems (GIS) concepts. *Journal of Geography in Higher Education*, 36, 527–545.

Steiniger, S. and Hunter, A.J.S 2013 The 2012 free and open source GIS software map – a guide to facilitate research, development and adoption. *Computers, Environment and Urban Systems*, 39: 136-150.

Taylor, P.J. 1990 GKS. *Political Geography Quarterly*, 9: 211-212.

Tomlinson, R.F. 1962 *Computer Mapping: An Introduction to the Use of Electronic Computers In the Storage, Compilation and Assessment of Natural and Economic Data for the Evaluation of Marginal Lands*. Report presented to the National Land Capability Inventory Seminar held under the direction of the Agricultural Rehabilitation and Development Administration of the Canada Department of Agriculture, Ottawa, 29-30 November.

UCAS 2016. *UCAS Search Tool*. Available online (accessed 25/11/16): http://search.ucas.com/

Unwin, D. 1989 *Curriculum for Teaching Geographical Information Systems*. Report to the Education Trust Fund of AUTOCARTO Royal Institution of Chartered Surveyors, University of Leicester.

Number of Course Codes including Geography in degree title	F800 BSc Geography	L700 BA Geography	Only other course codes	Number of HEIs
1	14	9	16	13
2	32	29	10	13
3	-	-	21	12
4	2	2	10	6
5	1	1	8	27
6	1	1	1	6
7	-	-	2	
8	-	-	1	1
9	-	-	2	2
10	-	-	1	1
11	-	-	1	
12	-	1	1	1
13				1
14				1
15				1
	50	43	74	85

Table 1: Provision of undergraduate degrees with Geography in their title in British Higher Education Institutions, 2016.

Source: UCAS.

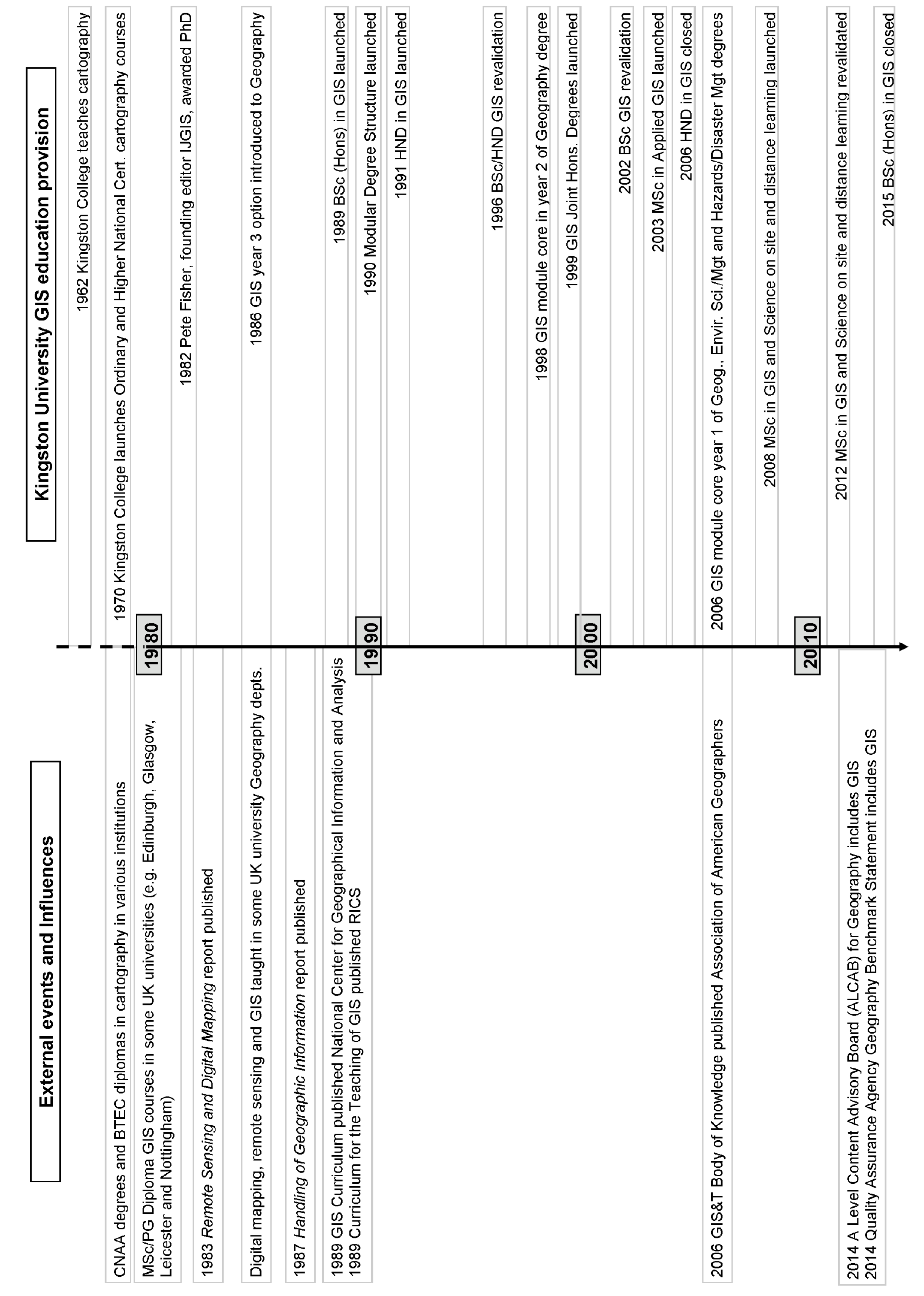
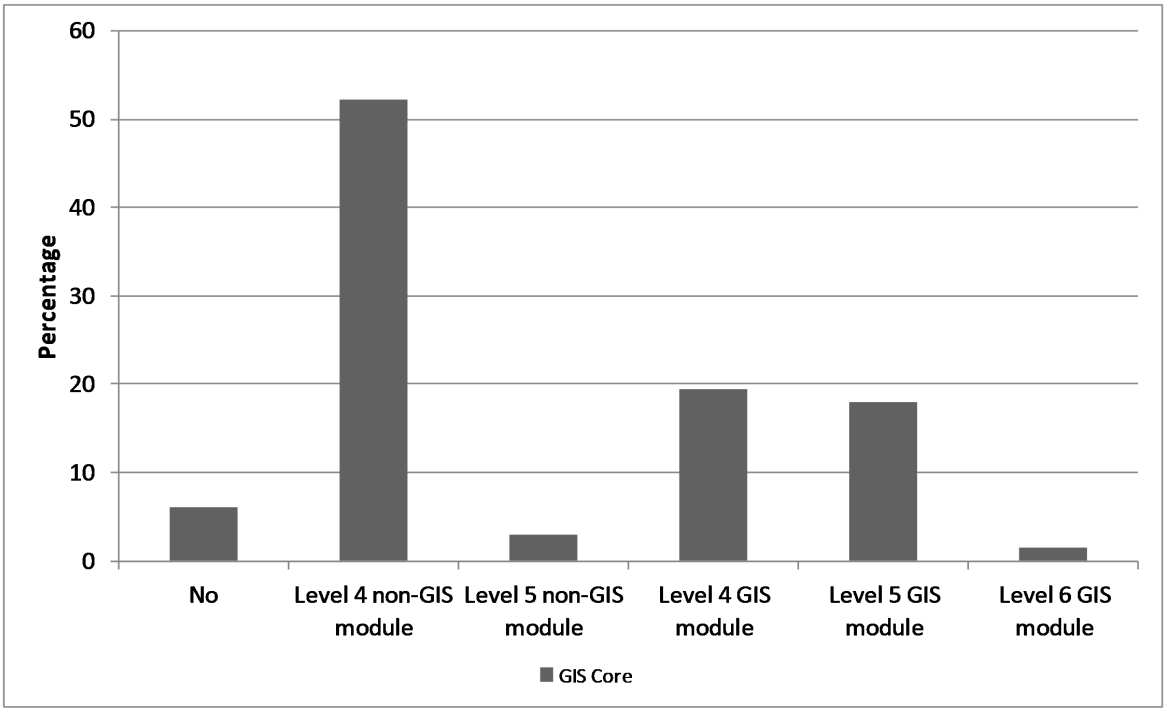


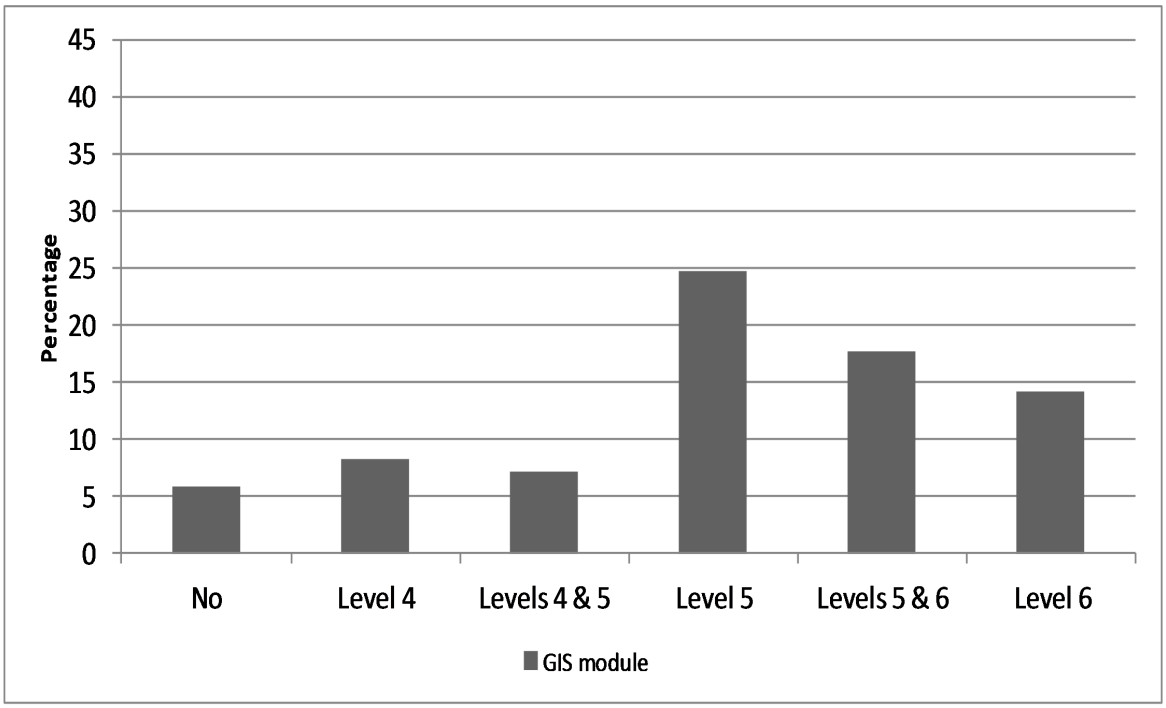
Figure 1: Timeline of GIS educational development and changed provision in case study Higher Education Institution.

Section	Sub-section
1 Introduction: the context of GIS	Definitions
	Data and information as a resource
	Illustration of GIS capabilities
2 Cartographic and spatial analytic concepts in GIS	Spatial data typology
	Georeferencing
	Map projections and transformations
	Two dimensional coordinate transformations
	Three dimensional coordinate transformations
	Fundamental spatial concepts
	Quality of spatial information
	Basic operations on points
	Basic operations on lines
	Basic operations on areas
	Basic operations on surfaces
3 Realisation in a computing environment	Digital representation of information – low level
	Digital representation of information – high level (file structures)
	Data models for spatial data – raster approach
	Errors in raster models
	Data models for spatial data – vector approach
	Errors in raster models
	Vector/raster debate
	Computing advances – expert systems
4 Operational considerations	Hardware overview
	Data storage
	Processors and processing environments
	Types of display
	Example of proprietary GIS
5 Applications of GIS	Applications fields
	Application at the global scale
	Making decisions using GIS
	Introduction to project management using GIS
	Costs and benefits in GIS applications
6 Institutional issues	Access to data
	Quality assurance and standard for data and systems
	Legal implications of GIS
	GIS and management
	Education and training for GIS

Source: Adapted from Unwin (1989).

Figure 2: Core curriculum for teaching Geographical Information Systems in the UK, 1989.





Notes:
Levels 4, 5 and 6 correspond to years 1, 2 and 3; GIS core means that the subject is compulsory at specified level either in a dedicated module or within another module.
Source: UCAS and individual HEI websites.

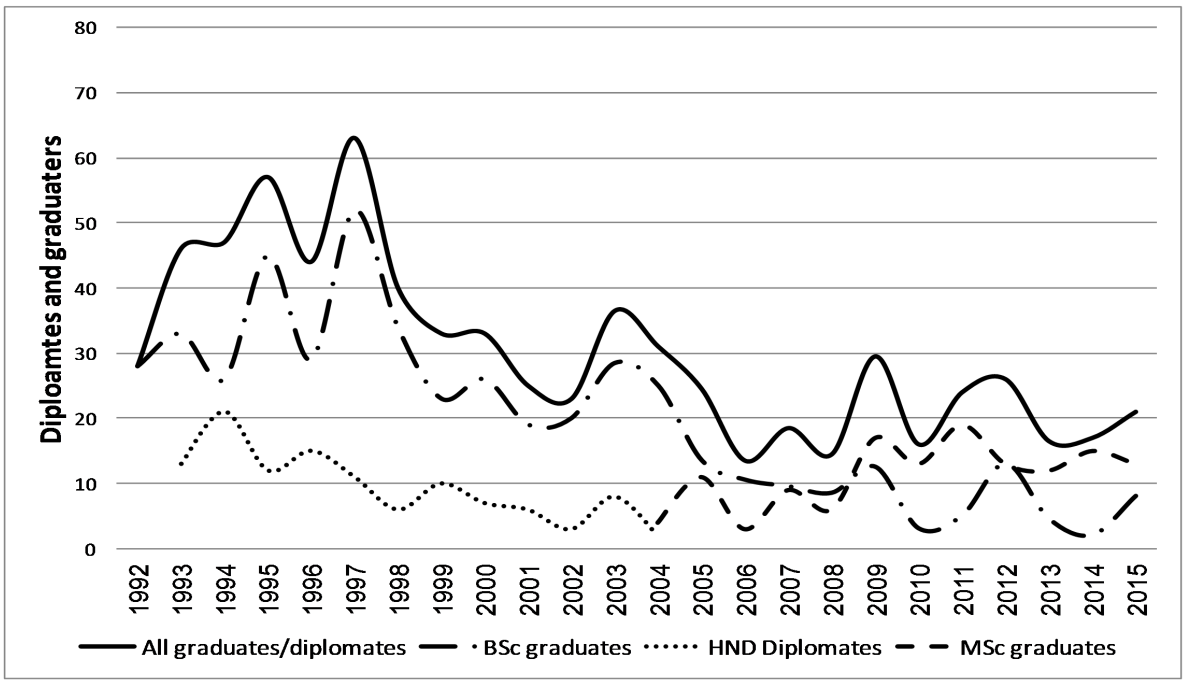
Figure 3: Provision of GIS education in degree programmes with Geography in their title in British Higher Education Institutions, 2016.

Themes	Year 1	Year 2	Year 3
	Integrative Assignments	**Integrative Assignments**	**Project**
Information collection methods	**Photogrammetry** **Remote Sensing** **Land Surveying** **Social Survey Design**	Photogrammetry Remote Sensing	Analytical Photogrammetry Analysis of Remotely Sensed Data
Data analysis and computing	**GIS: Principles and applications and digital mapping systems** **Computer and Information Systems** **Introduction to Spatial Data Analysis** **Mathematical Support**	**Databases** **Integrated Geographical Information Systems** **Advanced Spatial Data Analysis** **Organisations, Management and Budgeting** Intelligent Knowledge Based Systems	**Decision Support Systems** **Systems Analysis and Design** Integrated Geo-information Systems IKBS and Expert Systems
Information presentation and communication	**Cartographic Theory and Practice**	Advanced Cartographic Processes	Integrated Mapping Systems and Cartography
Environmental information	**Principles of Human Geography** **Principles of Physical Geography**	Social Geography Economic geography Land Use Planning Atmosphere and Hydrosphere Biogeography Landsurface Forms and Processes	*Advanced Urban Geography* *Agricultural Geography* *Coastal Environments and Management* *Applied Ecology and Pollution Studies* *Applied Hydrology* *Evolution and Conservation of the British Countryside* *Geography of Recreation and Tourism* *Industry and Industrial Systems* *Medical Geography* *Soil Management* *Transport Geography*

Notes:
Bold typeface denotes core (compulsory) unit.
Year 2: Choice of 5 from 10 options.
Year 3: Choice of 3 options from those underlined and 1 option from those in italic.

Source: BSc Honours Degree in Geographical Information Systems: Course Documentation. Kingston Polytechnic in collaboration with Kingston College of

Figure 4: Structure of BSc (Honours) Degree in Geographical Information Systems Kingston Polytechnic (now Kingston University) June 1989.



Notes:
Annual count of completions relate to the BSc (Honours) Degree, the Joint BSc (Honours) Degree (weighted as 0.5 FTE irrespective of whether GIS was a minor, standard or major part of their degree programme), the BTEC HND and the MSc in Applied Geographical Information Systems and Geographical Information Systems and Science during the years in which they operated.
Source: Author's personal documentary records.

Figure 5: Graduates/diplomates and annual staffing levels on BSc (Honours) Degree in GIS 1992-2015, BTEC HND in GIS, 1993-2004 and MSc in Applied GIS/MSc in GISS 2004-2015, Kingston University