Developments in getting GIS technologies into classrooms

BY LEX CHALMERS

Introduction

How long has the role of GIS in formal education been a topic of interest in geography conferences? We may be able to find evidence that suggests more than a quarter of a century, and few would suggest less than 15 years as an estimate.

If we look to Britain for the origins of GIS interests in education we may nominate publication of Peter Burrough's (seminal text in 1986], the Chorley Report of 1987 or the founding of the International Journal of Geographic Information Systems (Science) in 1987.

In North America it might be Howard Fisher's 1964 Harvard laboratory, Environmental Sciences Research Institute's (ESRI) launching of ArcInfo and a user conference in 1981 or the establishment of the National Centre for Geographic Information and Analysis (NCGIA) in 1988.

The point is not who was first, but rather the stage at which we started to look at how we train people in the use of GIS (the vocational thrust).

More recently we have pursued a second agenda in GIS instruction with interests in the secondary education entitlement of every student in the contemporary classroom (promoting the information technology society or the knowledge economy so beloved by politicians).

All of the above points have claims to mark a significant change: we can use them collectively as benchmarks against which to assess the current position of GIS in the secondary classroom, the issues we face, and the prospects we have.

The paper maps progress in the adoption of GIS in secondary education over more than 15 years. As it explores the incentives and impediments in the adoption of GIS in secondary schools, it notes the rich technology base in North America, and benefits of national geography curriculum and support structures in Britain.

It comments on factors that have been considered constraints in the past (hardware and software supply, data availability), and notes that some of these issues have been significantly addressed.

It then explores the residual impediments; the absence of a true home for GIS in secondary curricula, the failure to adopt a systematic national training programme for geographers with IT interests and the inability of teachers find time and commitment to explore ways of effectively using GIS in their classroom.

Throughout the paper there are references to two key texts that have underpinned this exploration of GIS in the classroom.

David Green's edited collection GIS: A Sourcebook for Schools (Green, 2001) and the Longley, Goodchild, Maguire and Rhind (2001) volume Geographic Information Systems and Science have been invaluable references and they contain numerous URLs that represent key sources of information for GIS teachers in secondary schools (all nominated sites listed in the references were accessible at the time of writing).

Finally, in the writing of this paper there have also been benefits from collegial discussions during an extended visit to North America and Europe in the second half of 2001.

Considering the issues and the prospects for GIS education in the secondary sector

As an inspection of the history of GIS in schools since 1987 reveals, no single impediment existed to prevent the teaching and use of GIS in the classroom at any point.

Equally, no publication, technological initiative or institutional change made the teaching and use of GIS inevitable. It is also naive to suggest that different education systems experienced the same impediments and prospects in the same sequence.

The consideration of issues and prospects for GIS in the classroom in the following sub-sections is, therefore, arbitrary. The approach does allow a discussion of issues and a mapping of the prospects for the future.

The discussion is based on the assumption that GIS is a distinct or 'marker' technology in education.

Internationally, the linkage of a contemporary technology (GIS) to a specific school subject (Geography) is not found elsewhere in the secondary sector, and we can argue for the teaching and use of GIS (mainly) in geography as a important plank in broad information technology education.

Hardware and operating systems: from Unix and command lines to the internet with point and click.

It is too easy to forget that for most of the past 15 years the major impediment to the educational use of GIS has been access to appropriate hardware.

We need to remember the days of CAD workstations and the Unix platforms on which the signal GIS software, ArcInfo, was launched in 1981.

Access to such hardware was restricted to university, research and major application agencies of government. It is worth looking back at the prognostications of 15 years ago.

Forer and Chalmers (1987) seemed radical at the time, but the change in (1) hardware operating speed, (2) storage capacity, and (3) price reductions have build an enormous market that means almost every classroom has some access to hardware that can drive acceptable GIS applications for geography.

Operating environments also changed. Command line philosophy may have been a natural progression for those who wrote FORTRAN and used subroutine libraries, but it was an almost impossible barrier for those whose primary concerns lay in the secondary geography classroom.

MapInfo (website at www.mapinfo.com/) launched the first desk-top GIS (PC) application in 1986 and the computing environment changed, with the menu-driven point and click quickly superceding the challenges of DOS.

At this point secondary teachers became seriously interested, and from 1990 there are many conference presentations foretelling the prospects of GIS in schools.

The impact of thin clients could hardly be foreseen, and the impact of the Internet operating environment in the classroom, particularly in the area of the teaching of GIS, is only just becoming apparent (Green, 2001, pp. 155-165. See also these internet map serving sites: Autodesk at www.autodesk.com with the mapping tutorial at www3.autodesk.com/adsk/item/0,,939476-123112,00.html, ESRI from maps.esri.com (includes some acceptable demonstrations), and Geoconcept from www.geo-concept.com/en/offre/sol_ii.html).

GIS map serving is established, but the sites visited in the preparation of this paper were a little unstable, and slow even within the benefits of a high speed Internet connection.

The IMS design and operating environment seems destined to grow rapidly to the ultimate benefit of distributed (classroom) users.

Internet map serving does not require particularly high hardware specifications; the key component for such a service is a high-speed communication.

Rural schools may be restricted to land lines with around 14kbps, but 56kbps is realistic for the interactive design and delivery of GIS analytical output using software and data held on a remote server.

With high speed (satellite) links now becoming more common, the school use of Internet map serving can only grow.

GIS software and the corporate interest

In the restructured economies of the last two decades technology corporates have led economic growth.

In my view, the current downturn in .com stocks and the performance of the NASDAQ are only minor corrections in a market that had become overheated.

The long term GIS project sponsored by Tomlinson, Fisher, McHarg, Marble and others (Longley, et al., 2001, p. 12) required a commercial response, and, almost inevitably, this arose in the environment of corporate leadership in the USA.

Corporates in CAD (drafting) and AM/FM (engineering services) both produced versions of GIS software, but ESRI's Arc/Info has a position as the marker product of functionally designed GIS.

GIS software quickly developed from the basic spatial functionality offered in the early 1980s; distance measurement, area estimation, pan, zoom and overlay are essential in the classroom, but the industry needs much more.

The capacity to link and operate on data in tables was provided from the outset, and some effort was made to ease access to spatial data of different types. Raster and vector data models were accommodated and integrated, and remote sensing provided access to new sources of spatial information and their analysis.

A review of the early annual ESRI Conference 'atlases' will show that the quality of the output available from first generation GIS software was modest, but the latest volume demonstrates what can be done with reasonably modest GIS technology and print production.

With reference to classrooms, the point of interest is when access to desktop GIS became a reality in secondary teaching.

The 1986 launch of MapInfo changed the operating base but not classroom access. In the first instance there were few teachers with appropriate skills, and GIS was still expensive, and generally operated on stand-alone (rather than networked) hardware.

In 1986 PC Arc/Info did not seem as attractive as MapInfo but the release of ArcView, an affordable, desktop-mapping GIS that sold 10,000 copies in the first six months of 1992, marks a significant point in GIS history.

ArcView continues to evolve, and is the standard against which GIS in schools is generally measured. MapInfo, and Geomedia promote an internet map server at *www.intergraph.com/gis/gmwm/* and Geomedia has also provided GIS software for schools and all of these corporates still see the benefits of early user exposure to their software.

In New Zealand and Australia MapInfo and ESRI products are the most significant GIS players in the school market.

Both support the international model of educational discounting and support for bona fide school installations and both have sought to make relevant spatial data available at a minimal cost to schools.

There are instances where the support for schools has extended into the most critical domain, that of supporting training and initial support for school projects, but the expense of this undertaking is recognised, and commercial imperatives have put some limits on this investment.

Geomedia represents a second tier of investors in school GIS. They provide a Workbook that includes (global) starter materials, including a self-paced tutorial and exercises. The Workbook also provides nine lessons, complete with data and detailed step-by-step instructions to give teachers confidence with the Geomedia GIS.

All of the software packages described above are proprietary systems that have not been designed necessarily with classrooms in mind. In Britain, the Advisory Unit for Micro-technology in Education developed AEGIS, a GIS framework customised for classroom use.

Two countervailing issues make this product interesting. The promotion of a system on a narrow technology base was laudable but (with hindsight) doomed as the price competitiveness of the PC emerged.

On the other hand, the provision of basic GIS functionality, with the capacity to enter field data onto national databases provided at the local level with customisable output formats, was very attractive.

The project has been sustained, and an attractive new format on PC (AEGIS 3) will be released for school use in 2002 (available through AGEIS at www.advisory-unit.org.uk/aegis3.html).

GIS data sources in the classroom

One of the biggest changes in the world of GIS in the classroom has been the data revolution. At the date of the Chorley report in Britain (1987), the prospects of getting a digital version of a data set appropriate for class use would have been limited.

The revolution has been three fold. In the contemporary world data collection is significantly digital, and an enormous volume of information is now available in a variety of forms.

Field devices (such as GPS) that are increasingly used to generate spatial data in the field are routinely interfaced to laptops and palm computers. Digital cameras are now also used to provide a field record in upper school geography, and have been in GIS projects submitted for national competitions.

The second series of changes in the world of GIS data supply to the classroom has been the mode of delivery.

While classroom data sets were initially small enough to fit on floppy disks, the 'Knapster' and MP3 generation (*knapster.sourceforge.net*) and comment on the debate from website (*www.zdnet.com/zdnn/stories/comment/0,5859,2578878,00.html*) are completely familiar with complex data formats and digital data transfer.

Proprietary data sets generated by national agencies may be provided on CD, especially where data sets have been customised for the classroom or user, and where license agreements relating to the use of the data have been agreed with school or institution.

The range of spatial data providers has broadened enormously.

In Britain, Internet sites running Apache applications serve street maps, aerial photographs and include route-finding options between specified addresses as a routine service.

Registration from *www.edina.ac.uk/admin/registration.html* may be the best site, with quality aerial photographs, but similar facilities are at *www2.getmapping.com/* and *www.streetmap.co.uk*).

While these and related services are not formal GIS platforms, they are very much part of the spatial data handling revolution.

But the third change has been the most radical, and almost international in its reach. As recently as five years ago in New Zealand, major agencies of state such as the keepers of the national cadastre (LINZ), environmental databases (Landcare Research) and Census data (Statistics New Zealand) held quite conservative positions about the distribution of 'their' data.

Many factors contributed to the weakening of this stranglehold, not the least being the challenges from private sector providers and the prospect of on-sellers adding value to basic data sets.

When coupled with the Internet revolution, we can see how the legal access limits on classroom data have now almost evaporated.

Two interesting outcomes of the democratisation of data supply are found in ESRI's Geography Network facility (www.geographynetwork.com/) and the GLOBE programme (www.globe.gov/). ESRI's project is an effort to create a global database of accessible information at a variety of scales and provided with basic metadata.

The promotion of ArcView as the viewing and analysis tool of choice with these data is consistent with ESRI's wish to serve the education market, and the position is enhanced with the provision of free entry-level software.

The marketing benefits of this strategy are acceptable where the beneficiaries become a generation of users comfortable with the use of spatial data.

The Globe project collects and distributes international data on a set of environmental measures. Teachers are trained formally, and the philosophy is to share the collection of environmental data at a common scale; GIS applications use Globe data in the classroom.

GIS and school curricula.

There have been significant concerns internationally about the development of secondary school curricula in the last three decades.

It has been argued elsewhere (Chalmers, Kent & Keown, 1990) that this has been a function of a new focus on the teaching and learning experience and a broadening of the expected educational outcomes from schools to include vocational as well as academic achievement.

Geography has been somewhat battered by these experiences, and many national reporting systems have registered a decline in numbers of students taking the subject.

Unwin and Dale (1990) reported on efforts to formally include GIS as part of the geography curriculum in the process that operated in England in 1990, but it is worth noting that these efforts produced nothing specific in what was an overly prescriptive and somewhat unpopular statement.

Revisions to the UK secondary curricula have opened up the options, and there seems to be few curricula impediments to the use of GIS in the classroom.

The experience in Northern Ireland has been rather different. The following commentary paraphrases the promotional material associated with their GIS experience (www.osni.gov.uk/giscd.htm)

'In September 1996, GIS became part of the Key Stage 4 Geography requirement in Northern Ireland and the natural progression of the subject into A Level Geography is likely to be swift.

In addition, the Ordnance Survey of Northern Ireland (OSNI), in conjunction with the Northern Ireland Education Support Unit (NIESU) have supplied teaching and learning materials to cater for changes in the geography curriculum.

This includes a PC based interactive multimedia tool that brings GIS into the classroom. The GIS material is available on CD-ROM and contains an introduction to maps, an introduction to GIS and comprises a short history of the subject detailing its origins, growth and applications. Examples of GIS functionality – tools, data entry and storage are also included. More importantly, the package also contains two working GIS applications that have been selected for their relevance to work carried out at Key Stages 4 and 5 and these permit the interactive input of data'.

As a declaration of intent in GIS curricula development and support, this statement is notable.

While it is more difficult to characterise the Geography/GIS curricula directions in a fully federal system like the United States, there are two institutions that have made significant contributions to the structural development of GIS education.

The first of these was established in 1988 when the National Science Foundation established the National Centre for Geographic Information and Analysis (NCGIA) (www.ucgis.org/).

The primary mission of the NCGIA was to conduct basic research, but the organisation also had the mission to expand and strengthen geographic information science education at all levels.

This mission has been executed in the preparation of the SEP (Secondary Education Project) by the NCGIA (see *www.ncgia.ucsb.edu/education/projects/SEP/sep.html*).

However, along with the University Consortium for Geographic Information Science, the NCGIA has been driven primarily by the vocational needs of GIS training at the tertiary level.

Tom Baker (2001) provides a well-documented account of the history of classroom GIS in the United States. He confirms the international experience of the broadening in teaching approaches (as described in Britain), and points to the importance of the National Science Education Standards of 1996 as the point at which GIS assumed greater importance in the secondary (K-12) curricula.

This assertion is supported by the activities of GIS corporates who have targeted their investment at the K-12 level in the United States. Baker points to many examples where the inquiry methodology has been combined with GIS technology to generate excellent projects; science education is the driver and not all these projects are undertaken in Geography.

The K-12 curricula are broad enough to allow GIS to be used where appropriate, and corporates acknowledge this in GIS promotion. The ESRI site which is a typical K-12 resource (*www.esri.com/industries/k-12/index.html*), and Clark University promote the useful Idrisi as a K-12 GIS solution (*www.clarklabs.org/07school/07school.htm*).

In contrast, New Zealand's experience in the use of GIS has been predominantly in Geography.

The curriculum is still effectively a 1975 NGCC outcome, so the opportunities to use GIS must be threaded into familiar teaching approaches.

There were efforts to write independent 'unit standards' for GIS in the early 1990s, but these languished. Equally, in the assessment-based introduction of the National Certificate of Educational Achievement for Geography Levels I-III (2002-2004), there are opportunities to use GIS, but no formal statements about how or why such approaches might be considered important in geography.

GIS and the professional development of geography teachers

A significant number of the current geography teacher cohort received their subject specialist training in the era in which GIS was entering the tertiary institutions.

Not many of those teachers who developed specialist interests in technology and GIS in the early 1990s are teaching in geography because many have moved into areas like local government where there is a demand for GIS skills.

Professional development is a prospect for those who do not currently have GIS skills, but (in New Zealand at least) other priorities that have assumed greater importance.

Many of these PD courses are associated with the new assessment and quality assurance systems; few are involved with subject expertise.

As a consequence, many geography teachers are on the wrong side of the digital divide and students with limited subject expertise have far greater technological competence.

With a much wider concern about the place of subject expertise in teaching (acknowledging the need for generic pedagogical skills), the role of technology training for geography teachers in general (and for GIS in particular) is a very important issue.

Some leadership in this area is called for, and the obvious responsibility rests with the policy agency that administers education (in New Zealand, the Ministry of Education). The potential solutions for professional development in this area may lie with the technology itself.

There are arguments supporting the importance of face-to-face teaching, but the potential for professional development through the web go beyond efficiency and into the domain of effectiveness.

There are any number of GIS courses on the web, although most are inappropriate for professional development of geography teachers because they focus on vocational and industry models.

The best modelling of technology for teachers is that developed for teachers and the British model (BECTA) (*www.becta.org.uk/*) is a robust example of this approach.

BECTA not only focuses on the role of technology in the classroom, but also uses the technology to deliver geography resources (*www.becta.org.uk/*). Given the size of the educational community in the UK, it is not surprise to find LEA supported sites (*www.sln.org.uk/geography/*) with a wealth of geography education resources.

The teaching environment

Alongside a change in GIS technology, there has been a significant change in the classroom environment in the last 15 years.

Working directly to the national curriculum is one pressure teachers face, and they are also driven by increasingly rigorous assessment protocols.

But perhaps a bigger change has been on the accountability and quality assurance procedures that have been put in place in most secondary school systems.

The benefits have been primarily in improving performance at the low end of the distribution, but this has perhaps been broadly at the expense of innovation and the opportunity to incorporate technologies like GIS in particular.

The Internet has eased some of the bottlenecks associated with the provision of classroom resources.

While the volume of resources is immense, there are few that can be downloaded and used directly from the Internet. Adaptation to the particular teaching context is an inevitable requirement, but the variety and currency have replaced the limits of sets of class texts.

Geography teachers should bookmark key sites, especially those that offer links to a range of resources. In Australia, exemplary sites include links to any number of data sources, teaching models and applications of GIS (see, for example, the Australian site (*www.scu.edu.au/schools/rsm/staff/pages/shartley/workshop/*) and this site complements the Becta and Staffordshire sites noted above.

Burkill's (1996) commentary on ICT in the geography teaching environments raises some concerns. The change in the technology since the COBRIG meeting will have had an impact since 1994, and many more GIS-capable computers will have been delivered to school classrooms. However, while the technology continues to change at breakneck speed, the broader classroom environment changes more slowly. Inquiry-based learning in the digital classroom is an unrealistic goal for most geography teachers, and the virtual learning environment (VLE) promoted as desirable in tertiary education is 'over the horizon'. Physically, the goals are definable, but in terms of managing the classroom environment for effective learning, we have to set realistic goals.

Conclusion and prospect

What, then, is the function of the text above? Much of the historical review is known, and many people have discussed the promotion of GIS in schools. It could be suggested that it is time to stop talking and get on with teaching and learning with GIS in the secondary sector. Such a suggestion is appropriate for schools that are well equipped, with GIS-familiar teachers and teaching plans that allow classroom use of the technology.

Such a suggestion is probably also the fervent wish of those who administer curricula and assessment frameworks.

However, it overlooks some of the issues that remain to be addressed in almost all national educational systems. Until we look at these matters seriously, we run the risk of short-changing those who invest time and efforts in the classroom.

Clearly, we have fewer concerns about GIS hardware and software access, given that many schools (and most teachers) have access to appropriate computing systems.

The speed of Internet connections is perhaps the residual concern. It is also apparent that data provision has been significantly democratised in the last 10 years, and key information sites routinely have guidance as to the terms and conditions under which data may be freely accessed. The battle for data access is in its final stages.

Curriculum developments in GIS remain problematic in many places. There is a case to be made for the introduction of GIS in a much wider curriculum area than Geography alone, and some support for positioning GIS in the technology curriculum.

The counter to this suggestion is that concentrating technology in one area defeats the purpose of a broader education that sees technology used in the areas to which it is relevant.

This point is as important in art and language teaching as it is in Geography. While the teaching of Geography requires cultural awareness, it also needs understanding of the nature of spatial analysis, particularly in field studies.

The concerns of Pickles (1995) notwithstanding, core geographic skills include cartography, field measurement and spatial analysis. GIS is the technology tool that supports the development of these skills.

The final concerns lie in the area of teacher training and classroom environments. While those who teach Geography at K-12 in North America, years 11-13 in New Zealand, or Key Stage 3 and 4 in Britain are generally Geography subject specialists, the new emphasis in teacher training in the last decade seems to have been in generic pedagogy and compliance.

Without professional development support in the subject content and skills areas, the capacity of teachers to adapt GIS-based projects to their classroom needs is significantly constrained.

References

Baker T. (2001) *The History and Application of GIS in Education* from the KanGIS K-12 Community at kangis.org/ed_docs/gisned1.cfn

Burkill, S. (1996) Trends in school geography and information technology. In Rawling, E. & Daugherty, R. (eds) *Geography into the 21st Century*, pp. 217-234. Chichester: John Wiley and Sons.

Burrough, p. (1986) *Principles of Geographic Information Systems for Land Resource Assessment.* London: Longman.

Chalmers ,L. Kent, A. & Keown, P. (2001) *Geography and Perspectives: Opportunities for teachers using the Internet.* Paper prepared for the AGTA Conference, Melbourne, Australia.

Department of The Environment. (1987) *Handling Geographic Information.* Report of the Committee of Enquiry Chaired by Lord Chorley. London: HMSO.

Forer, p. & Chalmers A (1987) in *Southern Approaches: Geography in New Zealand.* Christchurch: New Zealand Geographical Society.

Green, D. (2001) Geography GIS and the Internet. Green, D. (ed) *GIS: A Sourcebook for Schools.* London: Taylor and Francis.

Green, D. (ed). (2001). *GIS: A Sourcebook for Schools.* London: Taylor and Francis.

Longley, P. Goodchild, M. Maguire, D. & Rhind, D. (2001) *Geographic Information Systems and Science.* Chichester: John Wiley and Sons.

Pickles, J. (ed) (1995) *Ground Truth: The Social Implications of Geographic Information Systems.* New York: Guilford Press.

Unwin, D. & Dale, p. (1990) *An Educationalists View of GIS.* AGI Yearbook, 1990 and Unwin, D. and eight others (1990). *A Syllabus for teaching Geographical Information Systems.* International Journal of Geographical Information Systems. 4, 457-466.

Acknowledgement

I am grateful for the comments on a draft of this paper provided by Dr Munir Morad, Department of Geography at Kingston University, United Kingdom.