

Developing spatial literacy in secondary education: GIS practicals for key stage 3

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1. Introduction

Geographical Information System (GIS) technologies have been identified as 'one of the three most important and emerging scientific fields (Gewin, 2004). Whilst GIS and geographical information science are important in their own right, it has been shown that they can support students learn a range of more generic skills. For example, spatial reasoning tasks undertaken within GIS have potential to enhance maths skills; Lehmann and Juling (2002) found that increased spatial abilities are mirrored by increases in algebraic and arithmetical problem solving. Shin (2006) found that the development of GIS skills in the classroom helped to improve students' geographic knowledge. This improvement was found to be gradual but had sequential learning benefits in other areas. Further, Battersby et al. (2006) evaluated student understanding of the concept of map overlay, a set theoretical construct, and showed interaction between learning geospatial knowledge and complex thinking strategies.

The recognition of the importance of GIS as a vehicle for different skills, including spatial literacy and mathematics through representations of space and constructs such as set theory, Boolean logic, triangulation, co-ordinate systems, algebra and geometry, is reflected in the changing schools curricula for geography. The Qualifications and Curriculum Authority (QCA) in England has made explicit recommendations that encourage the delivery of GIS in schools from 2008/9 (Table 2).

Table 2. Qualifications and Curriculum Authority (QCA) recommendations for the delivery of GIS in schools from 2008/9

Stage	Recommendation
Key Stage 3	Students will ' <i>use varied resources, including maps, visual media and geographical information systems</i> ' (QCA, 2007a)
Key Stage 4	Students are to ' <i>become more independent learners through the use of geographical skills, new technologies and enquiry to serve them in their future</i> ' (QCA, 2007b) Teaching will embrace ' <i>use of new technologies including GIS, to assist geographical investigation</i> '
A Level	Students will ' <i>use modern information technologies, including geographical information systems as appropriate to the content</i> ' (QCA, 2006)

However, despite these recommendations, as yet few (if any) GIS software packages designed for use in schools offer little more functionality than a data viewer. Whilst this may be currently unproblematic, as curricula change (see below) and as students become more literate (the Google Earth generation) the teaching and learning resources needed will also change. Current software and teaching resources are not up to scratch in terms of true GIS functionality yet it is these missing analysis functions that arguably provide the most opportunity for the transfer of generic skills.

2. GIS in schools

There are many GIS software packages specifically aimed at schools and there are a number of online resources available to teachers. These include lesson plans, summaries of learning outcomes, handouts for students, exercises, etc. Similarly all of the software products aimed at schools come with a set of practical exercises, plus spatial data (typically current and historical OS raster data local to the school with some aerial photography) to augment teaching. From a GIS perspective (rather than a secondary educational perspective), the practicals that are available to teachers are very limited in terms of the GIS concepts they teach and the spatial literacy they promote. Typically, a series of lessons and practicals involves:

- Exploring a map – typically a raster data of an OS product at 1:25,000 or 1:50,000 scale);
- Identifying where students live on the map;
- Tracing a line with a mouse to create a line feature that describes a route you often take (this is usually ‘my route to school’);
- Measuring the distance using a distance tool;
- Selecting some data that fits some criteria (but note that, crucially, there is no functionality to create new data from the selected features);
- Printing the map for inclusion in a coursework folder.

Our concern is that the GIS software available to and targeted at secondary educational do not have a deep level of GIS functionality – the tasks listed above can all be performed in a standard image viewer such as Adobe Photoshop by an intelligent user. The tasks do not foster spatial literacy in students except at a very rudimentary level. In the terms of the NRC Framework (2006, p40-48), spatial tasks relating to the representation of features are facilitated, as are some limited means of comparison between static features, but the *transformational* aspects of a full GIS are not represented. Currently this is unproblematic since the use of GIS within a broader geography curriculum has to address the fact that many students arrive at secondary school unable to use spatial information at all. Furthermore, anecdotal evidence suggests that geography and spatial learning at primary school level are possibly the worst taught elements in the curriculum, certainly according to Ofsted (Ofsted, 2002).

Much early secondary GIS teaching has necessarily been based around a simple thread that it is expected will develop as the student progresses. Thus GIS teaching has been focussed to date on the development of spatial skills based on very simple ideas, such as reading spatial information (e.g. helping students to critically understand choropleth maps). From this starting point, students progressively develop more skills and capacity. Simple GIS functionality, such as the above, provides a stepping stone in this development, introducing the idea of layers, the connectivity between mapped data and the real world and acts as a useful prelude to the true functionality of a professional GIS. To these ends, and to their credit, much software designed for schools has particularly easy to use interfaces when compared to more serious contenders, resulting students being able to feel familiar in the software environment after only a short period of time. However, the current limitations of GIS software for schools (many will not even allow a simple distance selection or overlay operation) and the limited aspirations of the resources provided to teachers, who owing to

their own time constraints are likely to accept what is offered to them, preclude a deeper development of spatial literacy in secondary students.

A further dimension of the problem being addressed in this work is that few people who work on a day to day basis with GIS theory or geographical information science have been involved with the development of software and teaching resources for schools: typically, software developers have a background in IT and secondary education, or in the teaching of secondary geography. They are not GIS experts.

3. Method and results

In order to address this specific issue the Department of Geography at the University of Leicester developed and ran a set of 5 GIS practicals for Year 10 (Key Stage 4) with staff at Djanogly City Academy, Nottingham in September and October 2007. This collaborative venture involved the development of practical classes which brought together the GIS specialists knowledge and understanding of spatial literacy issues and the teachers understanding of the curriculum requirements and students prior knowledge and abilities. The practicals used data for the Nottingham area, and adopted Digital Worlds V2 software. This software has a true GIS functionality not found in most commercially available schools GIS software.

The practicals were specifically aimed at developing students' spatial awareness, the nature of spatial data layers and their understanding of GIS and spatial analytical techniques including spatial overlay, spatial queries and the use of sub-setting to create new data layers. These learning objectives were taught and developed using a series of discrete, self contained tasks:

- Understanding maps, and the concept of layers, using paper maps and tracing paper;
- Viewing data layers in a GIS and performing simple analyses by querying data, understanding thematic attributes and measuring distances;
- Classification and thematic queries through analysis, display census data, classification of data, normalization of data e.g. by area, querying by attribute;
- Spatial queries using distances, buffers, applying rules to generate queries to select layer objects, relating criteria to data, using multiple layers (MCE).

The practicals were merged into an established timetable, within which it was possible to find five 1-hour slots without causing disruption to the existing demands of the GCSE curriculum.

Each of the students in the class completed a learning diary at the end of each session. This aspect of the work was incorporated since the educational research literature strongly suggests that self-monitoring is a useful process for improving learning progress (Coutinho, et al., 2005; Brookhart, 2001). The structure for the reflective diaries covered specific aspects of the teaching and learning experience, asking the respondents on each occasion to describe 1) what they learnt, 2) what they have not learnt yet. They offered the opportunity to 3) ask specific questions and to 4) describe their biggest difficulties with the subject. The diaries also 5) capture information on learning or teaching progress (e.g. successes and disappointments). The information from the reflective diaries was collated and analysed to identify the positive and negative aspects of the teaching and learning experience through the case studies. Analysis showed that:

- Students enjoyed the practicals
- Students commented that exploring spatial data using a GIS gave them a better understanding of data (e.g. what are contained in rows and fields in a database) and existing applications e.g. web maps, gaming environments
- Students were fascinated by being able to 'get their hands dirty' with the spatial data that underpins many applications with which they were already familiar – Google Maps etc;
- Students were interested in the socio-economic patterns of their City, e.g. where the wealthy people live and expressed an interest in examining other types of census data;

A number of other issues also emerged from the learning diaries:

- A one hour slot is too short. The students wanted longer to examine the data and to develop their familiarity with the software;
- Running the software and loading data was too slow on laptops that were connected to the network through a wireless connection. Many students complained about these problems.

In the future the practicals will be run in a time slot with less pressure and on workstations hardwired to the network. We shall be looking to develop other applications relating to different curricula foci, for example practicals supporting existing field courses in Edale, climate change work, site location and looking at local demographics. There are further opportunities to develop mobile GIS applications, allowing students to embed their own data and information (e.g. photos) into a local and more participatory notion of GIS.

The focus of the practicals has been to try to use GIS as a means to improve the spatial literacy of students, whilst enhancing their spatial skills and their implicit understanding of the spatial world they live in. We believe that such 'GIS skills' are important in their own right, as well as being a means to an end for the QCA. One of the major issues encountered by this work for the development of student spatial literacy and their ability to use GIS techniques is the time and resources available to teachers for CPD training. Consequently one of the unexpected benefits of this work was the 'on the job' training received by the school teachers involved as they are under increasing time pressures with little resources set aside for their CPD. This highlights a wider issue: resources are needed to ensure that teachers' CPD keeps pace with fast-evolving technologies such as GIS.

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