Linking lessons learnt from the Spatially Speaking project with research findings on pedagogies with GIS

Introduction

The evaluation report for 'Spatially Speaking' highlights some useful recommendations for us to focus on as we start our second year of the project. This is a timely opportunity to engage further in a debate about the 'hows and whys' of developing our pedagogy with GIS. With this in mind it may be useful to consider evidence already available to us in other educational research literature.

Research findings on pedagogy and GIS

The application of GIS in geography education has been studied from a range of different perspectives. In universities, GIS are prominent features of most geography courses. However, school-based research often continues to highlight the factors which restrict our GIS use (Ordnance Survey, 2004). Many of us continue to associate GIS technologies with a steep initial learning curve and costly training. At the same time, some GIS teacher-innovators still find the lack of suitable UK data restricting.

Despite these often-cited barriers, research still suggests that when used effectively, digital GIS are powerful purveyors of geographical information (GI). The possibilities of providing students with opportunities to think and understand spatially with real world tools are particularly attractive to many of us. The level of development of their geographical thinking about both local and more distant places is strongly affected by the channels through which we present geographical information to them. Added to this important pedagogical consideration, a much wider range of rich spatially-related data can be held within one GIS than we as teachers are able to provide by other means. Increasing capacity to cache GI data on the Web has considerable potential to store and manipulate even more geo-referenced information more conveniently.

A growing body of the research literature also indicates that effective use of GIS can augment enquiry-based geography education (Baker, 1999; Kerski 2000). As well as being one of the key aspects of the National Curriculum; some researchers suggest that such a constructivist approach to learning stimulates students to use GI data more productively. In an enquiry-based classroom, the teacher is seen as facilitator and student peers are often engaged in collaborative learning. Linking and layering geospatial information becomes part of the overall learning process but also a pivotal aspect of student's own understanding (Baker, 1999).

Whilst teachers are becoming very used to the rhetoric of GIS it is important to emphasise that the reality of their own experiences often reflect the challenges as much as the potential benefits of using GIS.

'Despite its central role in real-world geography, GIS has had, to date, a negligible impact on geography education in schools' (Wiegand, 2001)

These challenges are not unique to GIS. Some research evidence also suggests that the connections between successful implementation of a technological innovation and the role of teachers in this process have not yet been fully explored. Even though ICT is widely evident in most educational settings, the challenges of developing effective pedagogic practices around digital technologies are considerable though not insurmountable. (Kankaanranta, 2005).

Although the UK curriculum provides plenty of potential for using GIS to support it, very little specific guidance exists on how to plan pedagogy around it. Already over-stretched teachers, many of them non-geography specialists in primary and lower secondary schools are unlikely to embrace GIS without a considerable amount of collaborative professional development and sustained infrastructural support.

Without wishing to stress the obvious, 'good teaching' is a complex activity. Subject teachers need to be cognisant with a range of areas of knowledge: their own subject content knowledge, knowledge about how students think and learn and increasingly in the twenty-first century classroom, knowledge about how to use technology. The importance of focusing on and unravelling this complexity is becoming increasingly evident in current educational research.

There are a wide range of factors at work which contribute to this complexity. The recent and continuing rapid rate of technological change can be hugely problematic in itself. Even when teachers are trained to use particular software packages, familiarise themselves with the intricacies of new or adapted hardware or painstakingly learn associated terminologies, their training can become swiftly out of date (Mishra & Koehler, 2006). Added to this, several software packages currently in use in schools were not designed with education in mind. This is particularly true of GIS packages (Bednarz & van der Schee, 2006).

Proactive pedagogies with GIS

In their recent examination of twenty-six cases of good practice across Europe, North America and Australia, Kirschner & Davis (2003) have addressed this difficulty. They

identified six significant benchmarks of teacher professional development programmes where teachers are trained to:

- become competent personal users
- become competent to make use of the ICT to organise data for students (e.g. via a GIS database)
- master a range of educational paradigms (models) using the ICT;
- competent in their use of ICT as a tool for teaching;
- master a range of assessment paradigms which make use of ICT;
- understand the policy dimension of the use of ICT for teaching and learning.

(Kirschner & Davis, 2003)

Their large-scale study suggests the need for a considerable deepening of teachers understanding and application of ICT before progress with pedagogy can be made. Research investigating the need to address the complexities of teaching with an ICT is not new. Several recent studies refer to Shulman's concept of *pedagogical content knowledge* (Shulman, 1987). Pedagogical content knowledge (PCK) describes the phenomenon where a teacher uses both their subject (content) and pedagogical knowledge together.

Recently, Mishra & Koehler (2006) have adapted this concept into a broader pedagogical framework to include a specifically technological dimension.
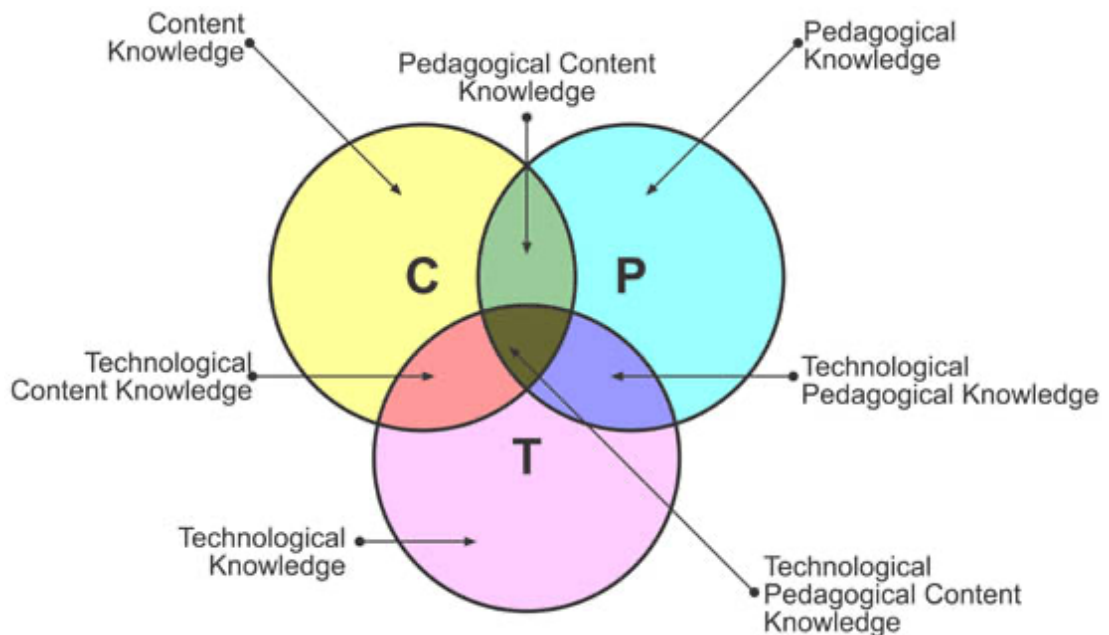

Figure 1 The Technological Pedagogical Content Knowledge (TPCK) framework (Mishra & Koehler, 2006)
http://tpck.pbwiki.com/

Mishra & Koehler's TPCK framework brings together knowledge about Content (C), Pedagogy (P) and Technology (T) as important inter-relating factors affecting the development of effective teaching with technology.

Content Knowledge (CK) is subject-based knowledge. Every subject has a specific core of central ideas and concepts that teachers need to be fluent with if they are to present accurate accounts of key content knowledge to their students (Shulman, 1986).

Pedagogical Knowledge (PK) has a broader significance including the elements of the art of teaching and theories about how individuals learn.

The intersection between content knowledge and pedagogical knowledge encompasses *Pedagogical Content Knowledge* (PCK) (Shulman, 1987). PCK is a more applied knowledge. When a teacher applies PCK, they are making qualitative decisions about effective teaching and learning *within their subject.*

Technological Knowledge (TK) involves the ability and competence to operate both simple and more advanced technologies. With specific reference to a more advanced digital technology such as a geographic information system, TK could involve navigating between raster layers or importing geo-referenced data from a website.

Technological Content Knowledge (TCK) requires teachers to be conversant with the ways in which technology can be applied to their subject matter. For example, a basic understanding of how geographical information (GI) is stored in vector, raster or hybrid GIS greatly facilitates clarity of a user's understanding about how data can be digitally manipulated.

Technological Pedagogical Knowledge (TPK) involves knowledge about how the use of specific technologies can be used to enhance particular types of teaching and learning. For example, a geography teacher with proficient TPK would be familiar with the pedagogical benefits of using Google Earth (the web-based earth viewer) for manipulating global images when teaching scale. Other teachers with different training or experience may be familiar with ArcGLOBE (an industrial strength GIS).

Technological Pedagogical Content Knowledge (TPCK) lies at the core of Mishra & Koehler's framework. TPCK requires technological competency, pedagogical skills and firm foundations in subject knowledge. But even more than this they suggest that:

'TPCK is a form of knowledge that expert teachers bring to play anytime they teach.'

(Mishra & Koehler, 2006, pp.15)

Part of the wider debate referred to in the project's evaluation report could consider whether identifying successful GIS-related pedagogies to enhance geography education is more likely to occur through consideration of a framework such as Mishra & Koehler's TPCK.

However, if we are to develop support for teachers using GIS further, consideration of a theoretical framework is likely to be only the beginning of the process.

'The need for teachers' professional development is clear but enabling teachers to adapt their pedagogical reasoning and practices in response to learning opportunities provided by ICT is likely to be a very difficult and complex process.'
(Webb and Cox, 2004, p.278)

There are a wide range of factors at work which contribute to the complexity surrounding a teacher's successful adoption of a technology. To re-emphasise the reality experienced by the teacher in the classroom, lack of time, inadequate infrastructural support and cost restrictions often result in teachers attending occasional workshops are unlikely to sustain or develop their progress.

Overall it would seem that developing teacher's skills with digital technologies in general and GIS in particular can be an exciting but challenging prospect. However, there is evidence to suggest that teachers do not engage with GIS for other reasons than simply cost and the complexity of some GIS software. Some researchers have suggested that difficulties experienced by some teachers confronted by the spatial querying that is an inherent aspect of using GIS is a specific area of teacher training that needs to be more specifically provided for (Bednarz & van der Schee (2006). Already over-stretched teachers, many of them non-geography specialists in primary and lower secondary schools are unlikely to embrace GIS without a considerable amount of professional development and sustained infrastructural support.

Collaborative professional support networks

A growing body of research evidence suggests that many teachers respond particularly well to continuing professional development where they can learn from other teachers (Crandall et al 1982). More specifically in this context, the benefits of school-based geography curriculum development through CPD are well-documented (Kent 1996; Rawling 2001). The acts of sharing new strategies at peer level can be powerful if complex processes contributing to professional learning (Groundwater Smith 2001). When teachers are pivotal, the processes of setting a collective agenda often become more readily transformative (Sachs 2003).

Evidence gathered from the first year of 'Spatially Speaking 'suggests that the chance to really focus on geographical information systems and their use in geography education has inspired and motivated both experienced and new GIS users to develop their GIS skills further. Of equal importance, the opportunity to take 'time out' from the other pressures of school gave participating teachers the chance to approach the associated challenges more freely. Being able to draw on ideas and experience from each other, representatives of the GIS industry and teacher educators has also been an important aspect of developing the project's support network.

One recent project which aims to address this need more comprehensively is the Advancing Geospatial Skills in Science and Social Science (AGSSS) scheme run by the Geography Department at Texas A & M University, USA. This support network aims to enhance the development of spatial skills in local schools. As part of this support, graduate students are invited to work as Advancing geospatial Skills in Science and Social Studies Fellows with teachers and students in the local community. AGSSS fellows are employed to undertake responsibilities which include regular and wide-ranging commitment to their partner schools. Their training includes guidance on effective mentoring in spatial thinking and induction course on school systems. Fellows become involved in curriculum development and evaluation as part of this shared learning. Teachers and fellows work together to design and implement research to evaluate the project and make recommendations for future curriculum development involving spatial thinking.

An example of a web- enabled collaboration based in the UK is the Schools Mapping Project developed by Durham County Council. The project won the Association for Geographic Information (AGI) award for Innovation in 2003. Web-enabled GIS technologies provide interactive cross-curricular geographic information to over 300 participating schools via a curriculum extranet (CNET). Teaching materials are provided on two levels, one introductory and one more advanced.

Another like-minded but larger-scale project funded by the European Union is the Geographical Information Systems Applications for Schools (GISAS) which has just been completed (2003-6). Seven countries were involved in developing ways to use GIS in secondary schools and teacher training. Schools from Belgium, France, Greece, Hungary, Italy, Latvia and Sweden map and share data about water quality via a web-based learning environment (WBLE). Surveys of participating schools faced many of the well-documented difficulties associated with GIS adoption in schools with lack of technical skills, geographical knowledge and time being identified as major barriers. Significantly, one of the successes of GISAS cited by participants was the sustained training and technical support given throughout the three years of the project.

Conclusion

   'A classroom that uses GIS as a problem-solving tool is a classroom in which the walls are invisible and the teacher and student assume roles that are non-traditional… Adopting this technology is not for the fainthearted. But integrating GIS into the curriculum rewards teachers by creating intellectually challenging and demanding learning opportunities.'
(Audet & Ludwig 2000)

Sustained success with the introduction of any ICT in education depends on a complex range of internal and external factors including: training, resources and issues around organisational methods and technical support (Minaidi & Hlapanis, 2005).

In the GA's 'Action Plan for Geography' the 'overarching goal' is described thus:

'To ensure that a clear vision for geography's educational potential and its relevance to the skills agenda and to life in the 21st century are understood by all, including the subject teaching community and educational policy makers at all levels, and that teaching professionals are enabled and equipped to realize this potential with pupils and to engage them with geography in an enjoyable way that they value.'
(Action Plan for Geography p.3)

Specifically, the Action Plan makes reference to the need for learning from current research about effective CPD for geography teachers using GIS.

When used effectively, GIS can provide comprehensive learning environments with proven potential for problem solving of real world relevance. The 2004 Boxing Day tsunami tragedy and the impact of Hurricane Katrina in 2005 were graphically showcased through the public media often via GIS. These examples illustrate to educators and learners the potential of these technologies for displaying and analysing GI and making powerful connections between places.

Giving geography educators every possible chance to succeed with GIS in their schools is possibly beyond the remit of a small collaborative CPD project. However, evidence gathered from 'Spatially Speaking' thus far has given project members many reasons for optimism. It seems likely that our starting points at the beginning of our second year of the project will be more sustained individual technical support for teachers new to GIS and our collective emphasis on developing effective pedagogies with GIS.

Mary Fargher, October 2006.

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