

**A study of the role of GIS in constructing relational place  
knowledge through school geography education**

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## **Abstract**

This thesis addresses a specific aspect of geography in school education, the role of geographic information systems (GIS) in supporting relational understanding of place. It does this by combining a literature-based conceptual analysis with schools-based empirical enquiry. The main research question that steers the thesis is: What role does GIS play in constructing relational knowledge about place through school geography education?

The research offers new insights on the ways in which teachers can use GIS in geography education to construct relational knowledge about place. Following a discussion of place, relational knowledge and GIS in both academic and school geography, a methodology for the research is fully explained and justified. A qualitative enquiry approach is adopted via a multi-staged design consisting of case study and practitioner research. Analysis of interviews with teachers and pupils, lesson observations and document analyses yields 'thick description' of constructing place knowledge through GIS.

A synthesis of the conceptual and empirical analyses provides the basis for a discussion of findings. Findings identify GIS as a powerful medium for relational spatial analysis in school geography but also reveal its limitations on relational constructions and interpretations of place. A model of geographical knowledge construction in GIS is presented as a device for developing teachers' critical engagement with GIS in school geography. The thesis concludes with a critical evaluation and recommendations for future study.

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I hereby declare that, except where explicit attribution is stated, the work presented in this thesis is entirely my own.

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## Chapter One Introduction

### 1.1 Introduction

This thesis seeks to clarify the role of geographical information systems (GIS) in constructing relational knowledge about place through school geography education. The purpose of this chapter is to provide both context and direction for the thesis; to outline its origins and to chart the subsequent course that the research has taken. The thesis questions the role of GIS in constructing place knowledge, particularly relational readings of it. Whilst research on the role of GIS in promoting spatial skills in school geography is well-documented, the role of GIS in studying place through GIS in school geography is underexplored. The thesis makes a unique contribution to the literature on the use of GIS in school geography by identifying the educational implications of constructing and interpreting relational place knowledge through GIS. Based on the conceptual and empirical findings of the research a model of geography knowledge construction through GIS is also presented (see section 8.3). The model is intended to be instructional for teachers and provides new insights on how GIS may or may not be used to support curriculum development in school geography.

### 1.2 Background

The thinking underpinning the thesis has been influenced by a number of key works in contemporary human geography including David Harvey's re-theorizations of space and place (Harvey, 1996; 2001); Doreen Massey's relational analyses (Massey, 1999; 2005), Ed Soja's spatially orientated postmodern social theory (Soja, 1989; 1996) and Jonathan Murdoch's poststructuralist interpretations of space (2006).

In her relational analyses on space and place, Doreen Massey explores ways in which we come to know place that I have found particularly useful in developing my thinking about the key foci of the thesis :place and GIS. She argues:

We know that we cannot understand the character of any place without setting it in the context of its relations within the world beyond. This is place meeting place; different stories coming together and to one degree or another becoming entangled....A global sense of place.

(Massey, 2002 p 2)

Massey's view of place as both unique and connected implies the concept with particular philosophical and educational significance. Throughout the thesis I argue that this kind of critical approach to thinking is essential for establishing a meaningful approach to relational thinking about place in school geography. Place lies at the heart of geography (Tuan, 1977; Creswell, 2004) and developing critical approaches to teaching and learning about place in school geography is part of geography's role in broadening young peoples' understanding of this key concept.

At a time when developments in geospatial technologies are growing rapidly, I also argue that school geography should reflect and use the educational potential that geographical information systems now have to offer. The digitisation of spatial data has transformed the ways in which geographical information can now be represented through information technology. New geo-technologies<sup>1</sup> have made place 'virtually accessible' to the individual internet user in ways that were not feasible until relatively recently. If we think back to the launch of Google Earth in 2005, we can see how this growth, influence and ubiquity of web-based geovisualisation<sup>2</sup> have become marked. Internet users can now interact with 'digital place' through an immense range of diverse application programming interfaces (API)<sup>3</sup>. The burgeoning of Neogeography<sup>4</sup> and volunteered geographic information (VGI)<sup>5</sup> has changed the volume and range of GI applications even further.

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<sup>1</sup> Geo-technologies is a broad term used to describe a range of geographically-orientated technologies which include GIS, GPS, earthviewers and hand-held digital devices capable of mediating GI

<sup>2</sup> Geovisualisation involves the use of a range of geo-technologies to support geographical knowledge construction

<sup>3</sup> The growth of geography-related API has become exponential since 2005. These include (amongst others): Bing Maps, Google Earth and Nasa World Wind.

<sup>4</sup> Neogeography (Turner, 2006) is the term used to describe volunteered geographical information constructed in Web 2.0

<sup>5</sup> Volunteered Geographical Information (VGI) is a term originally coined by Michael Goodchild (2006) to describe geographical information posted online by members of the public.

It is important that I clarify exactly what I mean when I refer to a 'geographical information system' throughout the thesis. First, GIS or 'geographic information systems' can be defined in a number of ways according to whether one considers a geographical system to include its physical components (hardware and software) solely or whether one acknowledges its human components (users, organisations, practice). I prefer the latter interpretation and will use it from this point on in the writing (for a fuller consideration of definitions of GIS see Harvey, 2008). Second, 'geospatial technologies' is an umbrella term that is often used to describe a wide range of geography-related digital systems. This includes GIS in the ways that I have already defined and other technologies such as virtual globes and remote sensing applications.

It is also important to distinguish the difference between GIS as a geographical information system as I have defined it thus far and the field of GIScience, the theory that underlies geographical information systems. It can be argued that the introduction of information technology in processing geographical information (dating back to the 1960s) brought the two academic disciplinary fields of geography and cartography together in the new field of GIScience. GIScience engages with the representation of spatial data and their relationships within a digital environment. The discipline embraces a distinct set of principles and procedures (which I consider more fully in Chapter 2) to manipulate digital spatial entities so that the end user can visualise and interpret them. Most significantly, advocates of GIScience argue that the tools of GIS can be used to ask questions about spatial relationships which simply could not be posed outside of the realms of GIScience applications (Schuurman, 2004).

Whilst I consider the evolution of geographical systems and their connections to Spatial Science in Chapter 2, it is also important to establish right at the outset another significance of representation and communicating geographical information through GIS. In the context of this thesis, the concept of *representation* is taken to mean the act of portrayal of a specific phenomenon – in this specific case – place- in a geographic information system (GIS). Many of our chosen representations about important geographical concepts such as place rely heavily on both geography and cartography, two closely related disciplinary fields. In both, mapping plays an essential part in how we come to know the world and it is important to establish which parameters are placed on geographical representation through cartographical abstraction and generalisation. All maps (and GIS representations for that matter) 'abstract' elements of viewed reality. We make choices about phenomena we wish to represent in a map or any other geographical representation of the earth. Some observed elements

are simplified, others are exaggerated depending on the purpose of the representation being created. Geographers and cartographers (including those using GIS tools and applications) follow principles and conventions which help them to generalise about the complexity of the world in order to make the purpose of a map or GIS representation clearer (Harvey, 2008).

According to the new National Curriculum Key Stage Three Geography programme of study, '[Geography] teaching should equip pupils with knowledge about diverse places, people, resources and natural and human environments, together with a deep understanding of the Earth's key physical and human processes.' (DFE-00193-2013, p 1) Geographical information systems are considered to have an important part to play in representing and integrating geographical knowledge in contemporary school education particularly with regards to their role in viewing, analysing and interpreting places and data. It is also acknowledged in the new Geography National Curriculum that GIS play an important part in interpreting a range of sources of geographical information, including maps and aerial photographs and imagery (DFE, 2013). In particular this implies a use of GIS which leads to pupils becoming competent in gathering, analysing and discussing geographical data and communicating their findings and applications of these in sophisticated ways. However, the most recent Ofsted report on geography: *Learning to make a world of difference*, noted that GIS use in UK schools is often limited and that only a few schools are using GIS to its full potential (Ofsted, 2011). Other school-based research on GIS has often highlighted the barriers to its use (Audet and Paris, 1997; Kerski, 2003; Bednarz and van der Schee; 2006). More recently, whilst more traditional and costly GIS remains difficult to access for many, the proliferation of free online GIS on a range of platforms (PC, laptop, network, mobile) has started to make digital geographical information more readily available (Elwood, 2009). Teachers and pupils are beginning to gain more access to the use of these technologies in the formal curriculum (Fargher, 2013).

Despite the challenges and the continued slow uptake of GIS, research evidence reflecting the pedagogical benefits of using GIS to enhance school geography continues to grow ( Bednarz and Bednarz, 2004; Doering and Valetsianos, 2008; Favier and van der Schee, 2012). It continues to be the case that many teachers associate GIS technologies with a steep initial learning curve and costly training (Baker, Palmer and Kerski, 2009; Fargher and Rayner, 2012). Where GIS is being used successfully in schools it is promoting spatial literacy (National Research Council, 2006); developing

enquiry learning (Scheepers, 2009); supplementing fieldwork (Favier and van der Schee, 2009) and enhancing pupils' visualisation of geographical phenomena in increasingly interactive digital environments (Lei, Kao, Lin and Sun, 2009).

In connection with the conceptual frameworks adopted in the use of GIS in schools per se and geography education in particular is the idea of applying the concept of 'geodesign' and normative modelling in using GIS in the school setting. Geodesign brings together science and design to examine the nature of the interconnections between humans and nature. Its applications are characterised by being cross-disciplinary and aimed at engaging GIS and related technologies in modelling and evaluating impacts on the environment and how to plan for alternative futures (Foster, 2009). The latter is an approach that continues to feature prominently in GIS use in schools, particularly in geography, science and social science. Collaboration between subjects using GIS is most marked in the US school education context where earth and social sciences bring together teachers of science and humanities subject. In particular, as map analysis and interpretation is made easier with new spatial technologies, more school subjects have embraced the potential of learning through spatial science enquiry. The ability of capture and analyse geographical data and display it as meaningful geographical information has led to more pupils in schools decision-making and problem-solving the 'whys-of-where.' (Milson, Demirci and Kerski, 2012)

In particular, pupils using these kinds of decision-making and problem-solving conceptual frameworks are able to access and use meaningful representations through GIS generalisation which would not be feasible outside of these kinds of spatial analysis environments (Harvey, 2008). The educational advantages of being able to compare and contrast spatial patterns therefore becomes an essential concept underpinning geographical education through GIS. With the nature of current use of GIS in school geography established, it is important to move this discussion on to the more precise influences on the thesis. As my research methods will show, I have focused first on teachers -specifically the influences of GIS on teacher practice - in an overall sense and with direct regards to how GIS has influenced their construction of place knowledge. Second, I have focused on pupils and how the ways in which their teachers have used GIS has influenced pupils' interpretations of place.

There have been some significant influences on how I have chosen to shape these research methods particularly with regards to my own perspectives on school geography education. First, I share the view of other critical school educators that knowledge constructed in schools is not neutral and is a direct reflection of the epistemology through which it was constructed. In my opinion, it



follows that the ontologies of knowledge that pupils engage with in schools are strongly influenced by these philosophical underpinnings. Peter McLaren has written at length about its importance in ways that I have found informative about how and why knowledge is created in schools. He argues that:

Knowledge acquired in school – or anywhere for that matter- is never neutral or objective but is ordered and structured in a particular way; its emphases and exclusions partake in a silent logic. Knowledge is a social construction deeply rooted in a nexus of power relations.

(McLaren, 2009, p72)

I take a similar approach to McLaren's view through the thesis; I look closely at how knowledge is structured – in this case through GIS – and how this affects school geography. In a broader examination of ways of thinking about the world, Nietzsche (in Birenbaum, 1992) discusses the essential nature of knowledge and how it can be understood in ways which he describes as being both 'interpretive' and 'perspectival.' His viewpoints informed my thinking as I considered the broad range of interpretations of place that exist in modern geographical thought. Nietzsche argues:

In so far as the word 'knowledge' has any meaning, the world is knowable, but it is interpretable otherwise, it has no meaning behind it, but countless meanings.

(Nietzsche cited in Birenbaum, 1992, p93)

Nietzsche implies that knowledge about the world can be interpreted from a range of different viewpoints. An acceptance that the ways in which we come to know the world is perspectival implies that understanding key geographical concepts such as place and space are open to individual interpretation, too -they depend on a particular set of epistemological parameters which determine the nature of ontologies being created. In a similar way, I argue that space created in GIS is largely a product of the positivistic philosophy underpinning the technology and the field of spatial science and has important influences on how teaching and learning geography can be constructed through it.

In a similar way, Dear and Flusty (2002) make a strong case for mindfulness with regards to the inextricable links between epistemology and ontology. They argue:

Space in this sense is constitutive of our ontologies and epistemologies; and, space itself is a social product. (Dear and Flusty, 2002, p 130)

It follows that, the way in which place is constructed through GIS in school geography is strongly affected by the way in which space is produced in GIS and the 'a priori' theory that underpins these processes. Throughout the thesis I question what I perceive to be the largely unchallenged philosophical assumptions underlying the use of GIS in schools, the ways in which 'space has been thought out' through it and the educational implications for pupils thinking about place. My concern is with how geographical knowledge is made through GIS in school geography and how these processes contribute to young people's geographical education.

Castree et al; (2008) present an interesting argument about how the creation of geographical knowledge can be more 'socially consequential.' They weave together the subject matter of geography, critical pedagogy and wider political contexts in a strongly connected nexus. They argue:

If that exceedingly heterogeneous group of people called 'geographers' have anything in common it is this (and it is inevitably generic, even banal): they are together engaged in an ongoing process of producing, sharing, reconstituting and distributing knowledge. This does not make geography a purely epistemological enterprise; on the contrary, the geographical knowledges that are our stock-in trade both arise from and inform our practical engagements with the world. (Castree et al, 2008, p 680)

In essence, Castree et al; imply that 'everything we do as geographers is potentially 'relevant' to the affairs of society.' I have used their statement, though aimed more directly at university geography to consider how the findings of the thesis could contribute to school geography education at a time when it is currently facing yet another stage of considerable curriculum change. School geography is at another significant crossroads in its evolution. The publication of the new National Curriculum (DfE, 2013), (due to be applied in schools in September 2014), the inclusion of geography in the English Baccalaureate and further planned changes in line at GCSE and A Level mean that school geography is involved in yet another significant wave of curriculum change. I argue that more critical and informed use of GIS, in its more conventional, virtual globe and hybrid guises, is an important factor to consider approaching new curriculum-making.

There is a rich and diverse literature on critical geography education, and though I do not intend to discuss this at great length at this point in the discussion, I do want to consider the specific significance of critical school geography education to the way that I have approached the research. Morgan (2002) provides a synopsis of the main features of this tradition which I have found instructive. He argues that there are five key elements common to the various versions of critical geography education: a fundamentally critical approach to the positivism that underpins geography education; an emphasis on the importance of values whereby a critical geography education aspires to be sensitive to key issues such as gender and race; the firm belief that critical geography educators draw on social theory beyond the realms of geography education per se, for example environmentalism, feminism and other ways of thinking that contribute more widely to the welfare of society and, the crucial tenet that *critical pedagogy* is an absolutely essential element of a critical geography education. The latter implies that *how students are taught* is as important as or even more important than what they are taught (Morgan, 2002). In this research I use a similar maxim to consider the role of GIS in school geography.

In its geography manifesto: *A Different View* (2009), the Geographical Association encouraged teachers to invest their specialist knowledge skills, expertise and energy into stimulating student interests and needs in ways that I have also found enlightening in informing my approach to the research. The type of young people's geography education that was illustrated in the manifesto is dynamic and challenging, inspiring a living geography for change in a changing world. Young people are seen as a pivotal in shaping the living geography promoted within *A Different View* which includes geographical understanding of alternative futures. The manifesto set out a strong argument that now would appear to be yet another crucial time for geography teachers to be critically aware of the significance of decisions that are made about directions to be taken in school geography.

Teaching and learning in 21<sup>st</sup> century school geography should encompass critical and expedient use of spatial thinking through geographic information systems (GIS). Young people's meaningful learning about pertinent issues such as climate change, geopolitical shifts and patterns of economic uncertainty require careful consideration of the significance of geographical context and both the specificity and the interconnectedness of place(s). Geography as a school subject is best placed to develop young people's relational knowledge and understanding of these, some of the most significant contemporary issues of our time. I argue throughout the thesis that critical use of spatial

thinking and GIS in school geography can provide valuable learning environments where current and inter-related questions about these important issues can be addressed.

The thesis also contends that teachers' critical awareness of the physical and philosophical limitations of worldviews constructed in GIS is crucial in school geography education. This perspective is built on the premise that there is a dissymmetry between the ways in which geographical information can be created in GIS and the broader range of ways in which geography teachers and educators may wish to deepen geographical knowledge and understanding about place.

Whilst I consider the evolution of geographical systems and their connections to Spatial Science in Chapter 2 (p. 10) it is important to establish at the outset of this thesis the nature of the relationship between GIS and Geography. Despite its power to manipulate, transform and analyse digital geographical data, spatial thinking and the use of GIS has often been criticised for limiting geographical thinking. Rather than providing an illuminating window on the world that some advocates of GIS in school suggest (Sinton and Lund, 2007); critics beyond the realms of school geography have argued that GIS is responsible for narrowing geographical perspective. There is a large literature on the epistemological and ontological limitations of GIS and spatial thinking which I consider more fully in the next chapter (see section 2.4.5). Essentially however, dissatisfaction focused particularly on the limitations that spatial science and the use of GIS placed on deeper ways of thinking geographically (Sui, 1994). Many believed that the geography constructed within this traditional type of GIS was both deterministic and closed. Critics argued that the inherently positivist nature of spatial thinking through spatial science and GIS had produced a technology which could quantify but not qualify – where social phenomena in particular could not be valuably represented (Pickles, 1995; Sui, 2004).

Whilst spatial thinking through GIS, its emphasis on quantification and criticism of its underlying positivism continue to be met with disdain by some in human geography it is important to note that this is not the polarised view that I take in this thesis. In particular, I acknowledge the significance of the complexity of what geographers can study and how we define our subject matter. Whilst in its purest sense, early spatial science may have rejected the idea that geographical enquiry was

ideographic and required instead a nomothetic framework which allowed us to generalise about our world (Schaefer, 1953):

Geography has to be conceived as the science concerned with the formulation of laws governing the spatial distribution of certain features on the surface of the earth. The latter limitation is essential.

(Schaefer, 1953, p227)

As I discuss in greater detail in Chapter 2, Schaefer was writing in the 1950s at a time when there was a growing dissatisfaction with the limits of learning geography through a regional lens in Anglo-American Geography. As Cresswell describes: 'Schaefer clearly wanted to be a scientist. Scientists always get respect.' (Cresswell, 2013. P 85).

As I also discuss at greater length in Chapter 2, the field of critical GIS has moved on somewhat from these more simplistic criticisms of GIS. With particular relevance to this thesis is first, the growing emphasis on the role of 'data science' in gathering, processing and making sense of information (both geographical and other kinds); the second is a more constructive approach which I view as combining human geography approaches with spatial science methods and which have also helped inform my methods in the research. According to Nielsen and Burlingame (2013), 'data science' incorporates both analysis of data and the development of new, adapted algorithms that can better use the vast array of digital data (geographical and otherwise) that is now becoming increasingly available to us. By the process of extracting the generalizable, data science principles allow us to make sense of complex data sets. Throughout the thesis, I argue that adopting these kinds of more critical and reflexive approaches demonstrated in universities could be beneficial with regards to GIS use in school geography. By engaging more critically with how knowledge can be constructed in GIS I argue that geography teachers may be better placed to develop the currently under-played role of GIS in UK schools.

Another influence on my thinking about how geography knowledge is constructed through GIS arises through my consideration of an earlier critique directed towards cartography but I would argue equally applicable to this discussion about GIS in schools. In his seminal critique: *Deconstructing the map* (1989) Harley encourages an 'epistemological shift' in our ways of looking at maps that is equally relevant in this discussion about developing

critical approaches to using GIS in geography education. In his writing about the influences of cartography on thinking he argues:

What have been the effects of this 'logic of the map' upon human consciousness?.....I believe we have to consider for maps the effects of abstraction, uniformity, repeatability, and visibility in shaping mental structures, and in imparting a sense of the places in the world. It is the disjunction between those senses of place, and many alternative visions of what the world is, or what it might be, that has raised questions about the effect of cartography in society. (Harley, 1989, p 287)

There is also a wider debate to be had here in relation to the ontologies in contemporary GIS, particularly with regards to the ways in which teachers may wish their students to engage with theories of place. GIS, particularly in its newer internet-related form can appear as though it is becoming more malleable digitally but is in fact infinitely more complex. Teachers using contemporary GIS are confronted with the technical challenges of using specialist conventional GIS alongside an increasingly wide range of 'volunteered geographies' in Web 2.0 which can be of very varied and variable quality. This is a compound picture of the considerable potential of 'geo-visualising the world' through GIS and its increasingly wide array of impressive digital imagery, Though discussing similar complexities now over a decade ago, John Pickle's comments on the connections between subjective interpretation or as he describes it: 'the mastery of the gaze' and the increasing variety of manipulable geovisualisation now available - 'the textual malleability of electronic images' led me to think even more closely about how knowledge structured through GIS influences young people's geographical education. As Pickles (2002) argues:

All the fights about power and desire have to take place here, between the mastery of the gaze and the illimitable richness of the visual object.' And it is precisely here – in the intersection of the mastery of the gaze and the textual malleability of electronic images – that geographic theory remains surprisingly silent, particularly about the ways in which GIS has begun to effect deep-seated changes in the discursive practices of the discipline, the broader economy of information, and the uses to which such imaging techniques are put. (Pickles, 2002, p 239)

With regards more specifically to the exact nature of the ways in which GIS processes and visualised geographical information, Francis Harvey's work on geographical integration, geography and GIS was informative to me in considering more overt connections between GIS process and place representation. Harvey (1997), expresses its significance in *relating information through GIS*. He states:

Geographic integration is fundamental to geography and GIS. It is the axiom underlying geographic enquiry as the study of the interrelationships of human and natural phenomena in the spatial domain. The synthesizing study of these relationships places specific aspects of a place in a more encompassing web of interrelationships at a location. (Harvey, 1997, p 77)

Geography is a synthesizing subject which relates the human and the physical in ways that are crucial in learning about the complex world around us (Castree, 2005). In the way that Harvey alludes to, and, as the research will show, the thesis pivots on the ways in which place – as a site of relations- is constructed and interpreted through GIS. Considering place and relations together is the cornerstone of the thesis and, *relationality* – at its simplest level - the concept of relating phenomena, underpins the research.

In its earliest stages, I began thinking about relationality in a number of ways. I interpreted it as covering a broad spectrum, from simple connecting processes such as *joining and relating* in GIS to a more compound phenomenon such as the complex field of *relational geography*. I argue that the common ground between the two is their inherent synthesis. I also argue that relevant to any discussion on integration and relationality in school geography is the very nature of *geography scholarship* itself. In their more general discussion, Johnston and Sidaway (1979) make a strong case for always keeping sight of this, the subject's broadest but also perhaps its' most important educational role. They argue:

The principal purpose of geography scholarship is (thus) synthesis, the integration of material on relevant characteristics to provide a total description of a place or a region which is identifiable by its peculiar combination of those characteristics. (Johnston and Sidaway, 1979, p 51)

As a geography educator, and a former geography teacher, I attach considerable merit to the idea of scholarly geography in schools. For me, meaningful teaching and learning about place(s) and young people being able to think relationally through geography are central to a 'good geography education.' This kind of deeper geographical knowledge and understanding has always been shaped by maps, images and stories as well as by individual experiences of places. In particular, geographers lay claim to place as location as a particularly significant medium through which to focus our understanding of the world. The full extent of gaining geographical knowledge and understanding involves a combination of direct experiences and cognitive interpretation of data about place (Fien and Slater, 1983). From an early age, individuals develop strong emotional ties with specific locations so that 'home', 'school' and other places become important phenomenological spaces. Young children draw distinct mental boundaries around places and attach significant cognitive information to them.

As I have already partially considered in the discussion, thinking about place is also perspectival and affected strongly by the channels through which geographic information (GI) is represented (Roberts, 2003). There is a strong educational significance of perspectivism in this research because, alongside their personal experiences it is largely the choices that teachers make about geographical representation that informs pupils' formal education about place. Cresswell (2004) encapsulates the significance of perspective in coming to know place:

Place is also a way of seeing, knowing and understanding the world. When we look at the world as a world of places we see different things. We see attachments and connections between people and place. We see worlds of meaning and experience. Sometimes this way of seeing can seem to be an act of resistance against a rationalization of the world, a way of seeing that has more space than place. To think of an area of the world as a rich and complicated interplay of people and the environment – as a place – is to free us from thinking of it as facts and figures. (Cresswell, 2004, p 11)

It follows that, alongside GIS, relational knowledge and place, pedagogy is also a key focus to be taken into account in this research. Pedagogy is a contested concept in school education and I do not wish to consider its debated complexity here. Suffice to say that throughout the thesis, I interpret pedagogy as a collaborative process in the way that Lusted (1986) defines:



The transformation of consciousness that takes place in the intersection of three agencies – the teacher, the learner and the knowledge they together produce. (Lusted, 1986, p 3)

The research is therefore underpinned by the key purpose of ‘critical exploration’ of the ways in which teachers construct place through GIS and how this develops pupil’s interpretations of place. In their text on critical approaches to geography: *Material Geographies: A World in the Making*, Clark, Massey and Sarre (2008) imply a similar critical emphasis on examining the geographer’s role in shaping representations that I have found helpful. They argue:

Whether we like it or not, our actions (and our inactions) have effects. Sometimes in big ways, more often in small ways, we are implicated in the production of this world. (Clark, Massey and Sarre, cited in Clark et al; 2008 p1)

In one particularly pertinent example of their kind of critical educational thinking, Clark, Massey and Sarre (2008) describe the ‘paradoxical form’ of globalization. They view globalization as an intricate and often dualistic phenomenon - made by human action; by inaction and interaction; and played out across the world at a variety of different scales. What is crucial in their thesis is the implication that viewing the world in this inherently relational way is a central part of a deeper and more meaningful geography education. This kind of approach fundamentally involves an acceptance of the social construction of knowledge and the role of individuals in making knowledge about the world. I make a similar argument through the thesis for geography teachers using GIS. Their actions or inactions contribute directly to the representations of place that they construct in geography teaching and learning which is why my research methods focus so closely on their practice.

The final critical emphasis on pedagogy in this section concludes this part of the discussion on more general influences on my research approaches and brings us to the more specific ways in which I identified the research questions that underpin the thesis.

### 1.3 Identifying a research question

My research interests in using GIS to study place evolved over both a long teaching career in secondary school education and my more recent experiences in working in higher education. The creation of more accessible desktop GIS stimulated my initial interests in digital representation, and,

as a subject leader and classroom teacher in schools in the early 2000s, I began experimenting with simple GIS in my lessons. The advent of faster and more flexible internet access further fuelled my interest in these kinds of digital geographies. Training in using GIS enabled me to develop my skills using GIS software not readily available to classroom teachers at that time. The combination of my teaching and my newfound experiences of using GIS prompted me to begin researching the nature of GIS in the classroom.

Earlier research experiences raised a number of significant questions for me in relation to the nature of the role of GIS in school geography education. First, my MA dissertation (Fargher, 2004) on developing spatial skills provided evidence of using GIS to support understanding of visualising spatial data. As an advocate of using GIS, in that study, I was interested in exploring how using spatial technologies could enhance geographical understanding. The research revealed more than I had expected in terms of GIS and its role in developing spatial skills. The GIS that students were using enabled them to examine a range of imagery of continental shelves at a range of different scales. Access to that functionality allowed students to think about connections between coastlines, tectonic plate margin zones and ocean depths in ways that I had always found difficult to create in pre-GIS classrooms. My conclusions indicated that using GIS can enable students to think about places in ways that extend beyond the scope of spatial skills acquisition. Although small scale, my findings suggested that abstract geographical concepts became more accessible to them via a combination of exposure to a range of *geo-* visualized data about place *and* their enhanced spatial skills. Though not necessarily a new feature of using GIS in school geography, the research led to my thinking more closely about how GIS influenced how teachers and their pupils could construct place knowledge through GIS.

In my MRes dissertation, (Fargher, 2006), I went on to research how GIS influences teachers' practice with a group of teachers involved in the Geographical Association's *Spatially Speaking* project. Part of that ethnographic research involved my observing lessons taught by participants in the project and interviewing them about the curriculum outcomes, benefits and challenges of using GIS to support geography teaching and learning. During the research, the on-going challenges for teachers wanting to use GIS with regards to technical issues, accessibility and lack of training became very evident. More significantly with specific relevance to this research, my growing experiences of using GIS made me start to question the educational value of using the technology in

wider geographical learning, particularly with regards to developing understanding of places.

There is a sense in which it was at that crucial early planning phase of my research that this thesis began to evolve into what it has eventually become, an exploration of how GIS can be operationalized to synthesise knowledge about place through geography education. My experiences of research and my growing grasp of the relevant literature led me further towards the research's central problematic. As I began to think more carefully about the nature of spatial thinking through GIS I also considered a seminal text that was published at the time, the American National Research Council's report: *Learning to think spatially: GIS as a support system in the K-12 classroom* (2006). The report clarified the nature of spatial thinking through GIS:

The key to spatial thinking is a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning. It is the concept of space that makes spatial thinking a distinctive form of thinking. By understanding the meanings of space we can use its properties (e.g. dimensionality, continuity, proximity, separation) as a vehicle for structuring problems, finding answers, and expressing and communicating solutions.(National Research Council, 2006, p12)

The type of spatial thinking advocated by many GIS practitioners implies a particularly distinctive approach and choice of pedagogy that can be used in geography classrooms. These are more easily transferable into activities designed to 'structure problems,' 'find answers' and 'express and communicate solutions.' (National Research Council 2006, p12). As the Research Council's statement and the views of many advocates (including myself) indicate, there is a strong case to be made for using GIS as a vehicle for developing important elements of school geography education. But as I will show throughout this thesis, there is also an argument to be made for teachers engaging more critically with GIS both as a technology and a social practice. In my early deliberations on choosing research questions, I began to lean more towards the view that through unquestioning use of GIS, pupils become very conversant with the mechanics of spatial tools but less versed in spatiality in a broader sense. The key point is that if an understanding of space is confined to using the properties of physical space: its dimensionality, continuity, proximity and separation then there is a level of inevitability about the narrowing of knowledge produced through engaging with this narrowed version of space. It is the nature of these kinds of limitations and their implications for learning about place relationally that the research sets out to clarify.

At that point in my early deliberations about the direction that I wanted the research to take, I raised the question: *How does thinking in these very specifically structured ways influence knowledge construction about place?* Based on this thinking I began to speculate further on the ways in which GIS only has a limited number of ways in which it can represent and address place and other key geographical concepts. Returning to Creswell's emphasis on place is a way of 'seeing, knowing and understanding the world' (Cresswell, 2004) the other logical questions for me to ask were: *How does GIS influence how teachers construct knowledge about place?* And: *How does GIS influence how place can be interpreted by pupils?*

#### 1.4 Main aims

The principal aim of this research is to clarify the role of GIS in constructing relational knowledge about place. It seeks to investigate the influence of the concepts, tools of representation and processes of GIS on constructing relational knowledge about the key concept of place in geography education.

The challenge applied more widely to school geography, below, could equally be applied to GIS:

So what of school geography – what can geography lessons contribute to helping young people 'frame' their thoughts about the world and their place in it? (Lambert, 2006, p 33)

In this thesis, I am posing a similar question about the role of GIS in school geography. As a result of the considerations outlined in this introductory chapter the overarching research question which steers this thesis is: *What role does GIS play in constructing relational knowledge about place?* The research addresses three further questions about the role of GIS in constructing place knowledge:

1. *How does GIS influence teacher practice?*
2. *How does GIS influence how teachers construct knowledge about place?*
3. *How does GIS influence how pupils interpret place?*

A key part of my achieving these aims has been to adopt a dialectical theory-building approach to the methodology underpinning the thesis. This design is firmly based upon the data being constructed

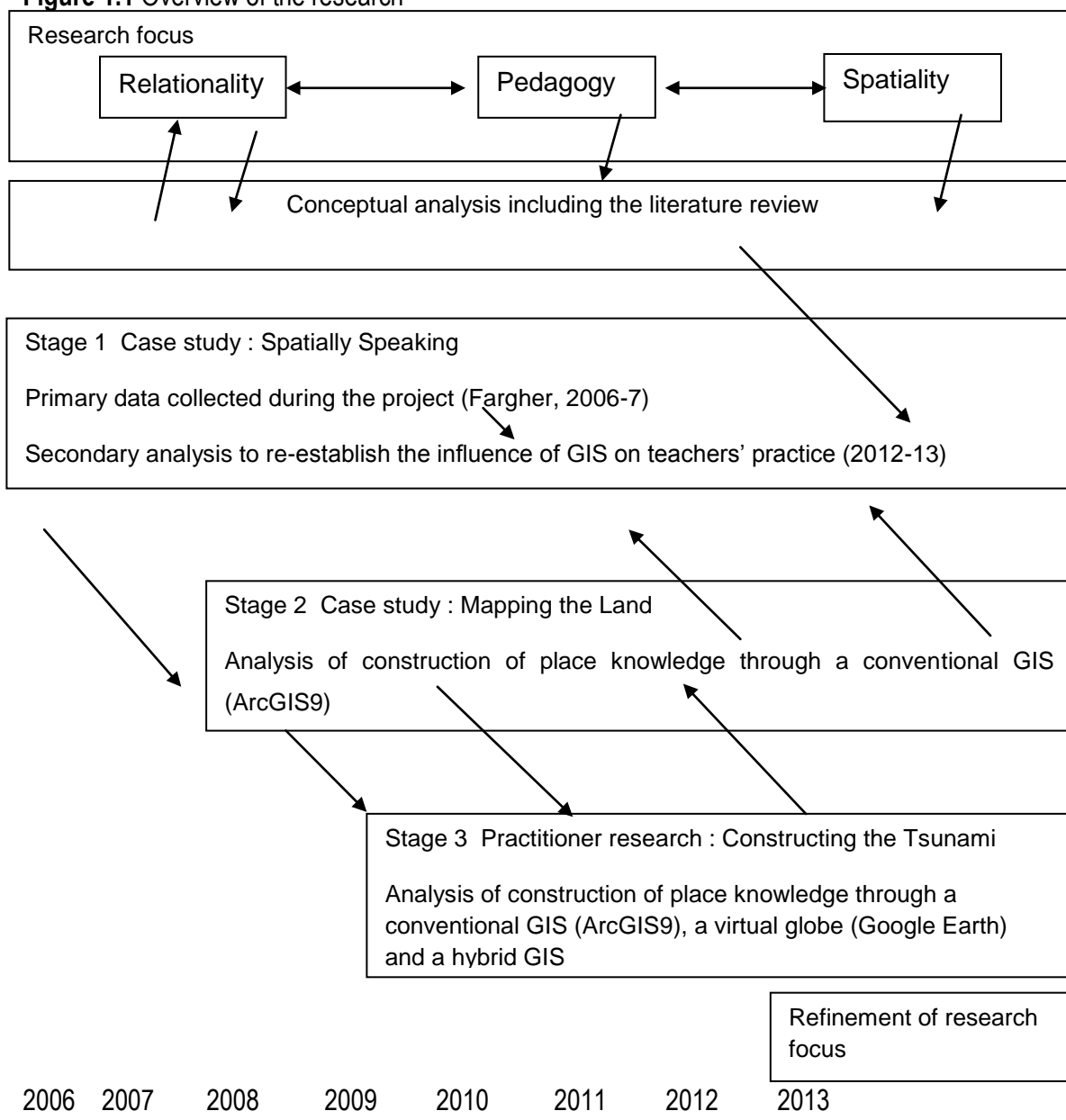
during the research in context and related to existing theory (Smyth 1998). This has been guided in the main by the key research principle of 'fitness for purpose.' In his discussion of this, Mac an Ghail (1993) makes an argument for this kind of approach to research methodology clearly:

Research activity should not be a static but rather a dialectical process, with methodology, data and theory informing each other. (Mac an Ghail, 1993, p 149).

### 1.5 Main Components

This introduction has provided a context and rationale for this research. It has also introduced the claim that geographical knowledge produced through geo-technologies such as GIS and virtual globes is increasingly significant in the contemporary geography classroom. It has argued that school geography continues to have an important role to play in constructing ideas of place; one that could be enhanced in the increasingly digital contemporary era through more critical use of GIS. Figure 1.1 provides an overview of the research and shows how its main conceptual and empirical components are linked.

**Figure 1.1** Overview of the research



As Figure 1.1 shows, the first main component of the thesis is a literature-based conceptual analysis (Chapter 2). I use the three broad research themes of *spatiality*, *relationality* and *pedagogy* to structure the thesis. It follows that the conceptual analysis is broken into two parts; the first examines the rich diversity of concepts of place and particularly the significance of relational thinking about place in geography and geography education. It further develops the theme of place as a social construct (Dear and Flusty, 1986; Harvey, 1996). It examines the key notion that place is a complex and contested concept that can be represented and interpreted from a wide range of perspectives (Hubbard, Kitchin and Valentine, 2004). It begins by providing a detailed analysis of the diversity of

place and space in Anglo-American geography. The discussion focuses particularly on the influences of spatial science (the paradigm through which GIS originally emerged), behavioural geography (a closely associated school of thought that developed almost in tandem with GIScience) and the critical responses of academic geographers who offered opposing philosophical standpoints. The analysis charts the alternate approaches to place emerging from a number of different schools of thought including humanistic geography, neo-Marxism, postmodern and post-structuralist geographies, presenting these alongside the then newly-emerging field of critical GIS.

The conceptual analysis then shifts in focus to examining ways in which place in school geography has developed via a number of influences not always in direct response to philosophical mood shifts in university geography. It examines the ways in which some approaches to place in geography teaching have been longstanding, particularly the traditional regional/descriptive paradigm that endured from the late nineteenth century until the 'new geography' of spatial science emerged in the 1960s and 1970s. The discussion considers how spatial science approaches to geography filtered through into some schools and set the scene for a 'new geography' of systems and analyses based on spatial models and concepts that informed the fundamental characteristics of geographical information systems (GIS).

The second part of the conceptual analysis examines key principles of GIS with particular regards to the nature of geographical representation in GIS and the documented role that it plays in contributing to the synthesis of knowledge in geography and geography education. The general principles of using GIS to represent geographical phenomena are then considered. Next, the chapter examines the academic field of Critical GIS (cGIS), discussing the central ideas underpinning historical waves of critique of GIS from their initial advent in the 1970s to the renaissance of cGIS in the 1990s; to the more recently re-sparked debates about the relative merits of conventional and newly-emerging GIS fuelled by the most recent emergence of GIS<sup>6</sup>. These critiques have always been primarily centred around philosophical questions about the value of knowledge creation through technology but have also moved on to consider narrowing the gap between technical challenges of GIS and the social implications of more less-skilled individuals using and creating geography-related information on the internet. Chapter 2 also examines reasons why these are relevant to this discussion about constructing place knowledge with GIS in school geography. For example, the discussion includes

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<sup>6</sup> GIS2 refers to newly emerging GIS that emphasises process and communication by users as well as the system itself (After Haklay, 2006)

consideration of the growing significance of Public Participatory GIS (PPGIS)<sup>7</sup> in supporting geographical learning about local environments. The discussion broadens with a discussion about the role of newly-emerging GIS, including earth-viewers and hybrid versions which, alongside more conventional GIS form an important focus in the empirical stage of this research.

The final part of the review on GIS examines the nature of GIS in schools, considering earlier research undertaken on its educational role particularly with regard to GIS enquiry, constructivism, optimal flow and cognitive load theory. The discussion then focuses in specifically on spatial thinking through GIS in schools, examining the ways in which specific types of the technology are used to represent and construct geographical knowledge at secondary school level. Finally, through consideration of Mishra and Koehler's TPACK<sup>8</sup> model (2006), it examines the opportunities and challenges for constructing place and other geographical knowledge through GIS in schools. The conceptual analyses, on place and on GIS, are used as a basis for informing the empirical enquiry that follow.

Chapter 3 gives a full account of the methodology underpinning the empirical enquiry. The first part sets out a rationale for deconstructing and interpreting the ways in which place is made and conceptualised through GIS. It highlights the central role of the teacher as curriculum maker<sup>9</sup> in the construction and representation of place in the classroom. It looks again to Massey and Clark's argument that geography educators are strongly implicated in 'making worlds' in the classroom (Massey and Clark, 2008). In particular, it argues that knowledge produced in schools is never neutral, but is represented and mediated in highly particular ways. In acknowledging the perspectival nature of knowledge production and to clarify the measured approach to choosing methodology, the chapter describes two of approaches investigated during the course of the research (including the measurement of cognitive load theory (CLT)<sup>10</sup> and grounded theory methods (GTM)<sup>11</sup> before the

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<sup>7</sup> Public Participatory GIS refers to volunteered GI on the web that can be used to involve non-specialist GIS users in developing GI.

<sup>8</sup> The TPACK model (Mishra and Koehler, 2006) examines how technological pedagogical content knowledge is constructed in the classroom

<sup>9</sup> 'Curriculummaker' refers to the role of a teacher as pivotal in developing knowledge in the classroom (After Lambert and Morgan, 2010)

<sup>10</sup> Cognitive load theory relates to the impact of a task such as acquiring geographical knowledge on an individual's cognition. The theory suggests that there is a strong connection with how a task is set up and how efficiently an individual is in carrying it out (Paas, Tuovinen et al; 2003).

<sup>11</sup> Grounded Theory method is based on the central claim that theory can be 'discovered' in the empirical world (Dey, 2004).



eventual adoption of a qualitative approach to dialectical-theory building (Figure 1.1 provides a snapshot of the main 'routes' for this approach to the research).

In spelling out the multi-staged nature of the research design, Chapter 3 demonstrates that though complex, the structure is designed to fully represent the dialectical theory-building developed as the research has evolved. Dialectical theory-building is evident throughout the writing that follows in subsequent chapters. The research investigates the role of three distinct kinds of GIS in representing and mediating place knowledge in school geography. These are a traditional GIS (ArcGIS9), a virtual globe (digital earth) and a hybrid GIS which combines elements of both of the latter.

The second part of Section 3 examines methods of data collection and analysis including consideration of the construction and analysis of lessons using GIS; observation, interviews with teachers and students and analyses of researcher journal documents and classroom documents. The chapter concludes with a section on the ways in which ethical issues have been addressed during the research.

In Chapter 4, the first case study (*Spatially Speaking*) focuses on a Geographical Association's GIS project. It draws on a secondary analysis of the research that I conducted with nine teachers participating in the project during 2006-7. In the analysis of six interviews with nine teachers and six school reports I identify key elements of their experiences of teaching and their pupils learning of school geography through GIS. Chapter 4 concludes with an interim summary of the findings from the case study. These are used to inform analyses in Chapter 7.

In Chapter 5, the second case study (*Mapping the Land*) focuses on one school (School A) where I observed a class of 22 GCSE Year 11 students using GIS and carried out document analyses and two interviews with their teacher during four visits to the school over a three month period in 2007-8. Chapter 5 also concludes with an interim summary of the findings from the case study. These are used to inform analyses in Chapter 7.

In Chapter 6 the practitioner research study (*Constructing the Tsunami*) focuses on another school (School B) where I taught a series of ten lessons to a Year 9 class (22 students), conducted participant observations, document analyses and carried out group interviews (11 in total) over a

period of three months during 2008-9. Chapter 6 also concludes with an interim summary of the finding from the case study. These are used to inform analyses in Chapter 7.

The discussion of findings is found in Chapter 7. In response to the three main research questions and through a focus on the three broad themes in the research: *spatiality*, *relationality* and *pedagogy*, the discussion draws on evidence from theory and practice to discuss how ideas of place are shaped through GIS. Through a synthesis of the conceptual and empirical analyses already represented in the thesis, it considers how teachers' practice is influenced by GIS, how GIS influences their construction of relational place knowledge and how this influences how pupils interpret place. It discusses the considerable educational potential of combining the scientific rigour of conventional GIS with more open-ended concepts of place and high quality visualisation through hybrid GIS.

Chapter 8 presents the main conclusions drawn from the research, provides a synoptic review of the main features of its course. A model of geography knowledge construction in GIS is then presented. A discussion informing pedagogy with the use of GIS in school geography and teachers continuing professional development with GIS follows. The chapter also summarises the particular contribution of the thesis to the field of geography education in schools. The chapter proceeds with a critical evaluation of the research, its connection to wider educational issues and makes recommendations for further research in the field. The final section of the chapter includes my concluding comments on the research as a whole.

## Chapter 2 Reviewing place, relational knowledge and GIS

### 2.1 Introduction

This chapter examines the role of GIS in the framing of knowledge and understanding of place in geography education. Chapter 1 provided an overview of the ground to be covered in this thesis and identified the central problematic of this research, namely the philosophical and educational tensions caused by attempting to represent and conceptualise relational readings of place through GIS. I began by spelling out the centrality of place and the significance of thinking relationally in geography and geography education. In particular, I provided a case for questioning the geographical implications of 'information systems' (Curry, 1998) in geography education. I indicated that human geographers in particular had already voiced concern over the narrowing of geographical perspective in spatial science per se (Soja, 1996, Doel, 1999, Schuurman, 2000).

I went on to describe that my early experiences of using GIS to develop pupil's spatial skills in geography lessons (Fargher, 2004) led me to question the broader educational benefits of framing geographical teaching and learning through the conceptual structures of GIS. It was curiosity about the latter (the focus upon which evidence in this research is based) which steered me towards investigating the construction of place knowledge in GIS and the ways in which geography-related pedagogy can develop in GIS-assisted lessons. I also indicated that the limitations of thinking geographically through GIS has already been raised by university geographers (Curry, 1998; Cosgrove, 2008), but that its potential shortcomings remain largely unchallenged in geography education in schools. I also noted that my growing scepticism about an over-dependence of using GIS to frame geographical learning during the Spatially Speaking project convinced me to pursue this line of enquiry in the thesis further. In this chapter, I aim to pursue these lines of reasoning further to explain as fully as possible the nature of the relationship between relational concepts of place and the spatial structures of GIS.

The analysis begins with a discussion on approaches to conceptualising both space and place in geography. I start with the latter because part of my central argument in this thesis is that there is a significant philosophical dissymmetry between the origins of GIS and elements of relational thinking in geography per se and place in particular. The analysis is based on the assumption that both space

and place are socially constructed and that spelling out the ways in which these key geographical concepts are theorised is a crucial cornerstone of this research.

The analysis also begins with a broad brush, acknowledging the broad range of perspectives on place and space in geography to give the reader a contextual overview of the literature review before focussing in specifically on the concepts of place and GIS which sit centre stage in this thesis. Two detailed reviews which form the majority of the writing in this chapter then follow. The first is devoted to considering concepts of place (with some consideration to concepts of place where relevant to the overall discussion on place and GIS), the second to concepts of GIS.

## Part 1 Place

### 2.2 Concepts of place and space

This section begins by examining the nature of space and place concepts and discussing a range of approaches to them in Anglo-American geography. It moves on to focus on the role of spatial science in shaping ideas of place because GIS originated in this area of geographical thinking. The attention then turns to an analysis of the interpretive frameworks of space and place that grew in the academy as critical responses to the 'new geography' of spatial science. The discussion focuses particularly on post-structuralist critiques of GIScience and GIS because it is from this school of geographical thought that broader, relational interpretations of space and place are also included. The review includes my making significant connections between relational knowledge, place space and geographical thinking.

Place and space are disputed yet central concepts for many geographers (Hubbard, Kitchin and Valentine, 2004). At the same time, the plurality of theoretical approaches to place and space reflect both their individual and their connected complexities. There is a vast literature on theories of place and space in geography. Figure 2.1 provides an analytical overview of key approaches to geographical thought and their implications for conceptualising both space and place through GIS. This broad theoretical context is useful in attempting to comprehend the complexities of how space and place have come to be viewed within geography. I argue that without this, it is difficult to

crystallize the complexities of how space and place have come to be viewed within geography and how these different standpoints have influenced (or not as the case may be) theoretical and ideological thinking behind GIS. In a similar way, the information displayed in the table is designed to provide a representative snapshot of each approach and to contextualise its significance in relation to other approaches.

Whilst acknowledging the importance of the range of approaches to space and place in geographical thinking, in the discussion that follows, it is fair to say that I examine approaches rather selectively. I focus on those which are most relevant to the central direction of this thesis more closely and taking a more fleeting glance at others. In Figure 2.1, the left-hand column lists approaches to modern geographical thought which have made particularly significant contributions to the ways in which space and place are theorized in geography. In the remaining columns, five characteristics demonstrate major elements of each approach including: the period of time within which each approach emerged (era); the intrinsic features of each (characteristics); schools of thought and theories which have influenced each stance (influences); key proponents of each position (advocates); and lasting contributions to the wider debate on place and space (legacy).



### 2.2.1 Place through spatial science

Until the 1960s, place and space were significantly less disputed concepts for most geographers than they are today. The 'new geography' that so shook established geographical thinking in the 1960s and 70s, coincided with and contributed to the first phase of development in GIS technologies. The essential nature of the thinking behind it was positivistic; its roots lay in a desire amongst many academic geographers for their subject to be recognised as a bona fide science (Unwin, 1992). *Explanation in Geography* (Harvey, 1969) was the first text which laid out the key elements of this scientific geography and articulated for its proponents and opponents alike an absolute interpretation of space. From his (then) positivistic stance, Harvey endorsed the scientific and quantitative approaches to space which had developed in geography higher education during the 1960s (Castree, 2004; Hubbard, Kitchin, Bartley and Fuller, 2002). A scientific geography based on theories of location, networks, spheres of influence, and spatial diffusion was constructed. That approach manifested itself in the creation of the spatial sciences including an early prototype of a geographical information system (Chorley and Haggett, 1965; Harvey, 1969; Gregory, 1978). Spatial analysis became the catalytic driving force steering this new geography.

The contrasts between the new and the old geography were conceptually stark. Whereas before, geography had relied in emphasis on classification and the uniqueness of the region, the 'new geography' favoured a systems approach to processes and patterns. Even those who did not embrace quantitative geography acknowledged that this was an important juncture in theoretical thinking about space and place. Substantial elements of those early positivistic approaches are still very evident in the ways in which GIS engages with spatial thinking and place today. It can be argued that GIScience, though evolving from that earlier form, has developed into something much more complex than looking at geographical space as purely scientific (Longley et al 2001). It is arguably too simplistic to think about such a complex field in such narrow terms particularly when one consider the application of GIScience in fields for example such as contemporary geodesign which incorporates so much more by bringing GIS skills and applications into a broad range of industrial and educational applications.

### 2.2.2 Place through humanistic geography

Some of the interpretative frameworks developed in reaction against the 'new geography' of spatial science were markedly humanistic with their emphases on place as a 'condition of human experience' (Entrikin, 1991) and as 'lived world' (Buttimer, 1993). Others revealed their phenomenological roots with place interpreted as 'humanized space' (Tuan, 1974) and 'event' (Casey, 1996). Many, when writing on space and place personalised their approach even further by locating themselves in their work (Relph, 1976, Buttimer, 1993). Seminal phenomenological research such as Tuan's (1974) *Topophilia* a study of environmental perception, attitudes and values and Relph's (1976) *Place and placelessness* highlighted the significance of social construction of place for the first time (Unwin, 1992). Humanistic geography steered others further away from a reductionist spatial scientist's view of the world, encouraging a fuller, more rounded geographical perspective of place (Creswell, 2004).



### 2.2.3 Place through neo-Marxist geography

Whilst the humanistic geographers focused their energies on the role of human agency, a neo-Marxist critique of the 'new geography' of spatial science also emerged. Its discourse focused less on the lack of emphasis of the experience of the individual in the quantitative/spatial paradigm and more on the lack of its acknowledgement of the role of structural conditions of social existence (Cloke, Philo and Sadler, 1991). The effects of Marxist theory appeared somewhat belatedly in geographical thinking, not really surfacing until the early 1970s. At that time, critics of the spatial paradigm in geography began to question its relevance to the social realities such as the Vietnam War and 'third world' famine. Harvey's theorization of space and place continued to be particularly influential. His revised thoughts on spatial science included the central tenet of space being a relative and constructed concept. The latter approach transformed geographical thinking for many in the 1970s and 1980s.

More recently, perhaps partly in response to postmodernist criticisms of his staunchly Marxist standpoint, his ideas on the production of 'geographical knowledges' have also made an important impact on the way space and place can be interpreted. In 2001, Harvey cast his critical geographical eye on the structure of 'geographical knowledges under globalization.' In a dialectical pursuit to identify common components of geographical knowledge, he focused on four: 'Cartographic identifications, the measure of space-time, place/region/territory and environmental qualities and the relation to nature' (Harvey, 2001). What is interesting about this later treatise is how Harvey identifies the range of ways in which even these four individual foci can be interpreted. These are deeply relevant to this discussion about the links between representation in GIS and ideas of place in geography as Harvey's categorisation implies the possibilities of a philosophical move away from the rigid objectivities of Cartesian perspectivalism towards more open-ended post-structuralist approaches to space and place.

### 2.2.4 Place through 'new cultural geography'

The post-modern 'cultural turn' also made significant contributions to the ways in which geography viewed the world. Like Harvey's analysis (2001) this watershed stage in modern geographical thought meant that for many, gone was the unquestioned objectivity of fixed 'geographical knowledge.' In:

*Poststructuralist Geographies: The Diabolical Art of Spatial Science*, Marcus Doel (1999) charts the influence of even more radical approaches to space and place in the discipline of geography and in the social and natural sciences as a whole since the 'cultural turn.' His critical exposition on the diversity of 'spatial science' is a reminder of the fundamental difference that individual perspective makes on how to engage with spatiality. He argues:

The chaosmos that we call a world can be folded, unfolded, and refolded in many ways. It remains for a geographer, for an origamist-cum-spatial-scientist, to take up some folds and experiment with their rhythm and consistency, their intensities and affects. Our duty as geographers is simply to make space for the deforming force of alterity and to open up space to the differential currents of dissimulation, disjuncture, and dissemination. Letting space take place. That is the ethic specific to poststructuralist geography. It is the diabolical art of a perverse, carcinogenic, and solicitous spatial science. (Doel, 1999, p199)

Doel's colourful but informative comments about 'letting space take place' reinforces the idea of space as a social construct that can be interpreted by not one but many perspectives.

In his contribution to the spatial science critique, Soja, a Marxist human geographer, introduced his concept of *Thirdspace* to highlight the role of more complex social interpretations of spatiality. He questioned the dominance of the established existential dualism of historicity and sociality in the construction of knowledge (Soja, 1996; 1998). His related definition of *Firstspace* implies a particular type of social construction of place that is reminiscent of many critiques of spatial science. Soja contends:

When captivated by such realist illusions, and, impelled by the presumptions of scientism, Firstspace epistemologies become fixated on the material form of things in space; with human spatiality seen primarily as product. Explanation and theory-building in turn derived essentially from the material form and covariation of spatial patterns, with one or more 'independent' geographical configurations 'explaining' the 'dependent' configuration or outcome in increasingly complex equations and causal chains (Soja, 1996, p 76)

Most importantly, these ontological restructurings of geography knowledge associated with the 'cultural turn' offered a more three dimensional view of the world as seen through geography and arguably pushed richer geographical thinking about space and place a little closer to the centre of the philosophical stage.

#### 2.2.5 Relational knowledge and place

The interpretation of place and space as relational is influential because as I will show in this part of the review, it underpins so much that is fundamental in geographical thinking. It is also viewed as controversial by some because, at the very least in its more post-structuralist guise where space (and by implication place) are viewed as compound products of a variety of interactions and interrelations (Murdoch, 2006). There are clear contradictions between this way of thinking and the positivistic approach to thinking out space which tends towards a more linear, deterministic view on how space can be made. Fuller discussions on the long-established philosophical debate on the absolute versus the relative nature of space are available elsewhere (Lefebvre 1991; Harvey, 1996; Soja 1989; Massey, 2005). Harvey (1996) makes a strong case for the relational nature of place. Part of his analysis includes a discussion of Alfred North Whitehead's writing on geometry in *The Concept of Nature* (Whitehead, 1920). Developing Whitehead's argument that spatial entities are created by processes and constituted from the relations between them, Harvey claims:

Place is defined as the site of relations between attributes. If so, then the argument for any kind of independent spatial science, in Whitehead's case geometry and in my case geography, falls away entirely. Whitehead regarded geometry as a branch of physics in much the same way that I regard geography as a general branch of the study of socio-environmental processes. (Harvey, 1996, p 263)

Harvey seems to be placing geography within the wider relational spectrum of people and nature in a way that further embraces space as being socially constructed.

In his landmark text: *Maps of Meaning* (1989), Jackson explores the role of geography as an inherently relational. His argument is based on perceiving the world as inherently complex. He argues:

Geography is conceived of not as a featureless landscape on which events simply unfold, but as a series of spatial structures which provide a dynamic context for the processes and practices that give shape to form and culture. (Jackson, 1989, p 48)

Jackson's argument further emphasises the significance of a more post-structuralist approach to relational thinking in geography by introducing the idea that this opens up more dynamic thinking about the world. This is also part of broad approach to interpreting place relationally which is evident throughout this research.

In: *Post-structuralist geography: a guide to relational space*, Jonathon Murdoch (2006) makes a strong case for geographers to consider more closely the complexity of relational spaces. He argues:

Space is generated by interactions and interrelations. Human geographers, then, need to account for the relational spaces that do emerge and they need to understand how particular spatial configurations are generated. Equally, some attention must be paid to spaces that do not emerge, to the sets of relations that fail to gain any kind of spatial coherence. Relations between relations therefore become important. (Murdoch, 2006, p 20)

It is worth pausing at this point in the discussion to explore further what this might mean for constructing place knowledge through GIS in school geography. In the opening chapter of this thesis, I introduced the significance of Doreen Massey's approaches to relational understandings of place and space (p\_). Massey's strong convictions too on relational place (Massey, 2005) contend that structuralist systems simply cannot accommodate ways of thinking relationally about space that transcend 'constructions of binary thinking.' She argues:

Thinking relationally is in part, an attempt to re-imagine the either/or constructions of binary thinking (where the only relations are negative ones of exclusion) and to recognise the important element of interconnectedness which go into the construction of any identity. (Massey, with the collective, 1999, p12)

A more open view on place that is not confined by a pre-conceived system could allow for teaching and learning in geography about relationships and society which cannot be easily translated within more fixed spatial structures. Throughout the thesis, I argue that less critical use of GIS to represent place can lead to limits on this kind of relational thinking.

In : For Space, Massey (2005) suggests an alternative view of space - ' a space of possibility' (Massey, 2005). This research is also based on the premise that space is generated by interactions and interrelations and that therefore there are significant limitations in GIS for thinking relationally about space and place. A common vein running through Massey's body of work – that of needing to understand the character of a place in the context of its entangled relations with other places is an important part of this discussion about a relational conceptualisation of place and the nature of the representation of place in GIS.

In her later text on urban places: *World City* (2006) Massey develops her argument about the intellectual challenges associated with defining, discussing and understanding relational place. She states: 'places are crucial.....maybe places do not lend themselves to having lines drawn around them.' ( Massey, 2006, p.18). Massey's idea of stories becoming entangled as 'place meeting place' has important connotations for how we frame geographical knowledges within GIS. In the light of a post-structuralist way of thinking, which rejects the binaries, so often presented in the positivist thinking that underlies traditional Cartesian GIS, my point here is that it is important that we challenge the thinking behind such a technology and question our use of it if it closes out eyes to more open ways of thinking relationally.

### 2.3 Place in school geography education

The historical perspectives considered in this section on place in geography education focus on guiding forces in the study of place in school geography over the last century. The following discussion considers the two dominant organisational paradigms, namely the regional/descriptive and the quantitative/spatial. In connection with the quantitative/spatial paradigm, the responses of behavioural, humanistic and radical approaches (and the cultural turn in particular) to studying place are also considered.

### 2.3.1 Regional /descriptive place

The practice of teaching geography through a regional framework became established in British schools at the beginning of the twentieth century and prevailed as a dominant paradigm until the 1970s (Graves, 2001). The regional approach was particularly influenced by the publication of Herbertson's seminal work: *The natural regions of the world* published in 1905. Herbertson produced a series of geographical papers between 1903 and 1913 which catalogued places mainly according to their climatic characteristics. Later editions of his works included regional classification of vegetation and altitude. Although physical geography continued to dominate his taxonomies, Herbertson did later acknowledge the relevance of human factors including population densities and economic geography. In 1905, the same year as Herbertson published his first paper, the Board of Education stipulated that school students should study distinct regions: Europe, America and Africa; and the regional contrasts between Asia and Australia within the context of the British Empire (Walford, 2001). Herbertson produced a number of popular school geography texts including *Junior Geography* in 1906 and *Senior Geography* in 1910 which outlined his regional classification for students across a broad age range. Over the next two decades, other authors including Archer, Lewis & Chapman, (in 1910) and Stamp (in 1930) emulated his methods (Graves, 2001).

Although the regional/descriptive paradigm was popular in the early decades of the twentieth century, it was not uncontested. Whilst the advocates of Herbertson's regional classification had welcomed the initial move away from the 'capes and bays'/gazetteers approach prevalent in schools, some felt that the regional approach was equally limited. Some geographers wanted a more thematic approach (albeit taught through a regional format). Mackinder had published his influential text: *Britain and the British Seas* in 1902. His book contained simplified remnants of the environmental determinism evident in nineteenth century geography. Mackinder advocated teaching prescribed places through a simple examination of the relationship between man and land (Graves, 2001). In 1909, Morley-Davis developed this thematic approach further with the publication of his school text: *A Geography of the British Isles with Numerous Practical Exercises*. His book set out to engage students in practical exercises about places and aimed to encourage students to 'reach conclusions of geographical significance.' (Morley-Davis cited in Graves, 2001, p.65). At the same time that some geographers taught about regions with a thematic approach, other, mainly physical geographers maintained a predominantly scientific stance towards regional studies.

Several persisted with a deterministic approach towards the relationship between the environment and peoples' responses to it (Simmons & Stenhouse cited 1927 in Graves, 2001). Images of distant places in such texts were dominated by the imperialist ideas which thrived but were rarely questioned at the time (Said cited in Graves 2001). Several texts including unchallenged description of places ripe for agricultural and mineral exploitation coupled with stereotyped images of local populations abounded (Graves, 2000). Although not motivated by this bias, some geography educators were becoming less and less convinced by the educational worthiness of the regional/descriptive paradigm. Fairgrieve argues:

No one man, even during a long and busy life, ever sets eyes on the whole of the world, and in geography we are concerned with much more than we can see. We cannot understand a fraction of the world unless we make an effort to imagine things as they are. (Fairgrieve, cited in Walford, 2001 p18)

Fairgrieve went on to publish *Geography in School* in 1926. His was the first textbook of the era to espouse an inductive rather than deductive approach to learning geography. In the text, Fairgrieve encouraged his students to do more than amass geographical facts about prescribed regions. Instead, he advocated using basic building blocks of information to develop their understanding of real geographical trends and patterns. His realist approach set the scene for three significant developments: the expansion of fieldwork; the introduction of audio-visual aids and the incorporation of sample or case studies of places (Graves, 1980).

The benefits of using fieldwork to bring school geography to life had already been investigated with some success in Scotland (Geikie, 1887 cited in Walford, 2001). However, fieldwork did not become more widely established in British schools until the 1920s (Walford, 2001). During the 1920s and 30s Laurence Dudley Stamp carried out the first and very influential Land Utilisation Survey. This project was the first survey of its kind to be undertaken by schools and helped to establish the importance of fieldwork in geography. Many other smaller-scale fieldtrips were organised by geography teachers keen to widen students' direct experience of places. Several enthusiasts including Sidney Wooldridge, Charlotte Simpson and Geoffrey Hutchings led excursions in their own time: The object of field teaching, at least in the elementary stage, is to develop an eye for the country (Wooldridge cited in Walford, 2001, p114). The emerging potential of using audio-visual aids was another aspect

of Fairgrieve's innovatory approach to teaching about places. Using pictures, slides, film and radio was an exciting prospect for teachers trying to bring distant places into the geography classroom. By the beginning of the 1930s, specific radio broadcasts with supplementary teaching materials were being produced by the BBC:

The whole of North America in four hours! That is the actual amount of time we shall be 'on the air' for the geography of a country eighty times the size of Great Britain. (Barbour cited in Walford, 2001 p105)

The regional/descriptive paradigm did not lose any of its dominance in schools during the war years. In a similar way to experiences during the First World War, places made more prominent by their significance as battle locations or areas of strategic territorial significance made geography seem very relevant (Walford, 2001).

Despite its critics, the regional/descriptive paradigm persisted after the Second World War. Stamp's textbook *The World: A General Geography* published in 1929 was still being printed in 1950. Stamp co-authored another influential school textbook series with L.S. Suggate called *Geography for To-Day* (published in 1937). Its format repeated the regional/descriptive framework including four books: *At Home and Abroad; The Southern Continents; North America and Asia* and *Europe and the British Isles* also presented geographical concepts and principles, (Graves, 2001). A rival to Stamp and Seagate's school text series was Reginald Honeybone's *Geography for Schools* (published in 1956). This series also followed the established regional/descriptive pattern but was distinctive because it combined a regional approach with 'a planned discovery method' (Graves, 2001, p104). This series invited student participation via activities embedded in the text. Places were represented as case studies with supporting maps and photographs. Though geography maintained its popularity at both university and school level a growing number of academic geographers began to question the continued dominance of prescriptive regional studies and deterministic exposition of physical and human geography theory. This relative stasis in geographical thinking was about to change radically.



### 2.3.2 Quantitative/spatial science place

The paradigm shift in academic geography which occurred between 1955 and 1975 (known as the 'conceptual revolution' or the 'new geography') was not a total transformation of the subject. Instead, this was mainly a human rather than a physical (geography) revolution (Graves, 2001). Whilst the positivistic philosophy underpinning the quantitative/spatial paradigm represented a significant change in direction for geography many of these theories were already well established in other academic fields. This radical conceptual shift in geographical thinking was accompanied by a burgeoning of new texts.

The work of several young university-based geographers such as Chorley and Haggett became very influential. A significant catalyst for change in school geography education in the 1960's and 70's was a series of summer conferences held for teachers. These lectures, organised by Chorley and Haggett, took place at Madingley, Cambridgeshire. When choosing participants, the organisers were keen to encourage younger and more recently qualified teachers. Their aim was to introduce them to a more conceptually-based scientific geography. They believed that quantitative methods and models were central to the delivery of a vibrant and relevant geography curriculum (Rawling, 2001). The 'conceptual revolution' first had an impact on the independent schools following the newly revised and more quantitative specifications of the Oxford and Cambridge examining board. Particularly at A Level, students began to study urban areas via quantitative methods and to be taught through hypothetical cases and simulations (Naish cited in Graves, 1980).

The emergence of the 'new geography' heralded by the Madingley lectures did not start to make a wider impact on other schools until the 1970s. Texts such as 'Settlement patterns' (Everson and Fitzgerald, 1969) and 'Frontiers in Geographical Teaching' (Chorley and Haggett, 1965) introduced school geography teachers to new quantitative ways of 'framing' and explaining the world around them (Beddis, 1983). In their introduction to 'Settlement Patterns' Everson and Fitzgerald suggested that: 'Teachers are beginning to realise that much of what is taught in our schools is purely repetitive and lacks intellectual stimulus and challenge to the student.' (Everson & Fitzgerald, 1969, Introduction). Having established that not all of the 'new geography' had to concentrate on statistics, many teachers began to move away from an emphasis on the regional towards a model and concepts-based geography. Even though this new approach was to be questioned by those still

championing regional geography, many agreed that it provided more opportunities for deeper geographical understanding (Beddis, 1983). In the preface of Everson and Fitzgerald's book, Haggett comments on school texts such as *Settlement Patterns* and their role in the re-incarnation of the quantitative/spatial in school geography:

This book shows a fresh and novel approach to settlement geography which links familiar spatial patterns to methods of analysis and stresses the excitement of individual discovery. (Haggett in Everson & Fitzgerald, 1969, Preface)

The so-called 'Madingley effect' stimulated much debate within the school geography education community. Questions focused on how opportunities for facilitating deeper geographical understanding were going to manifest themselves in this new geography where the tangible benefits were felt by many to be rather limited. Some teachers felt that whilst the more able pupils seemed to flourish through exposure to a 'more challenging geography', others were left floundering in its wake. Sceptics remained unmoved for more practical reasons based on a kind of justifiable inertia. In their text *Teaching Geography* (1966) two respected geographers, Long and Roberson declare a form of *laissez-faire*:

Meanwhile we have nailed our flag to the regional mast, and those who would not place the main emphasis on regional geography in school must justify themselves with some other viable philosophy. (Long & Roberson cited in Biddle, 1985, p19)

Somewhere between these two paradigmatic polar extremes, voices of the middle ground began to express other fundamentally pedagogical concerns about what should form the basis of a geographical education. Many felt that placing academic rigour based on quantification at the core of geography had somehow pushed the centrality of place out onto the subject's periphery. With this extraction came an additional and unwanted abstraction which amounted to an almost blurring of the fundamental features of the face of human geography (Marsden, 1996). In short, some felt that geography was in danger of dislocating itself from real places (Walford, 2001). As the voices critical of the spatial/quantitative paradigm multiplied, some began to speak from an increasingly behavioural stand point.

### 2.3.3 The influence of behavioural geography

In the late 1960s, behavioural influences in geography grew as a response against the old regional/descriptive and in connection with the new spatial/quantitative paradigm. Despite the impact of the recent spatial/quantitative incarnation of geography, advocates of a behavioural approach to geography were not satisfied with it. Whereas it might be challenging academically, they argued, its theories and models did not actually encourage a firm grip on reality. With their emphases on a world built on economically rational decision-making they bore little resemblance to the many worlds of geographical difference experienced by individuals. Thus the behavioural geographers offered a different perspective, one which was based on a more human-centred view of the world and where the geographical significance of an individual's environmental perception and behaviour could also be considered (Fien and Slater, 1983).

### 2.3.4 The Influence of humanistic geography

Some critics of the 'new geography' suggested that the associated emphases on themes and models also shifted the subject away from rote learning of facts towards a deeper understanding of place (Beddis cited in Huckle, 1983). Not for the first time or the last, the central educational aim to teach about place in context not simply as content surfaced. Some felt that the ways in which geography was being presented in school excluded significant humanistic and radical ideas (Rawling, 2001). Throughout the 1970s, partly in response to this concern, humanistic geographers attempted to

examine and extol the richness of the private geographies of the individual with their inherent emotional and intellectual connections with place (Huckle, 1983).

### 2.3.5 The influence of radical geography

By the early 1970s, another significant movement in geography in higher education surfaced. Amongst geographers on the political left growing reaction being to build against the scientific-positivist tenets of the quantitative/spatial paradigm. Alternative opinions on contemporary social welfare issue emerged as 'radical geography'. Reiser (cited in Walford, 2001) argues:

Spatial analysis with its odd-shaped bag of tools (seeks) data virtually irrespective of social and historic content on which to perform its new-fangled technical wizardry. The very content of the world is abstracted into quantitative geographical space, allowing status-quo views of the world to pass for scientific observations and analyses. (Reiser cited in Walford, 2001, p 184-5)

By the mid-1970s, radical ideas such as 'welfare geography' began to surface in school geography. As a result, a new debate about how associated values and attitudes should be re-represented to students began to influence the position of place in the subject and the changing shape of the school geography curriculum as a whole (Walford, 2001).

### 2.3.6 The School Council projects

The 1970s was a pioneering period for curriculum development in school geography. The government-funded Schools Council projects were key contributors to this innovation. Three of these were particularly influential: Geography for the Young School Leaver (GYSL); Geography 14-18 and Geography 16-19. A common characteristic of all three was their firmly thematic approach – taking the subject presented in schools one step further away from the old regional geography (Rawling, 2001). In the GYSL project in particular, a flavour of the new geography remained with some use of

spatial models and concepts, but was approached with a behavioural attitude – space – its patterns and processes were there to be discussed, to be personalised.

Within the context of a broader underlying humanistic philosophy, the student and their environmental perceptions and behaviours were placed at centre stage (Fien and Slater, 1982; Rawling, 2001). GYSL was organised around three themes: 'Man, Land and Leisure'; 'Cities and People' and 'People Place and Work.' Each theme was resourced with teacher guides, work-sheets, maps, photographs, slides, films and other materials about key local, regional and global locations. The provision of these resources proved to be hugely popular particularly in the teaching of less-able students (Walford, 2001). However, some criticised the potential pedagogical pitfalls of providing students with unquestioned resources which unless properly explored and discussed could leave students with unwanted negative perceptions about these locations (Boardman, 1985). The Geography 14 – 18 Project was designed with more able students in mind. The course reflected the 'Madingley effect' with an emphasis on models and hypothesis-testing but with a ground-breaking approach to examining students' understanding of place. The project's examination rubric states:

Some of the questions probably contain information about places which neither you, nor the other candidates, have studied in detail. This should not prevent you from answering these questions; it is not your factual knowledge of these places which the examination is trying to test, but your ability to use skills and ideas and to interpret and apply information.

(Walford, 2001, p 177)

This synoptic approach to the study of place remains evident in many examination specifications today (Walford, 2001). The key questions and guiding concepts of the extremely successful Geography 16-19 project were firmly focused on the specifics and importance of both place and space. Students were encouraged to learn through active but teacher-supported enquiry.

### 2.3.7 Place in the National Curriculum

Prior to the introduction of the National Curriculum in 1991 there had been considerable concern about an under-whelming emphasis on place in the school geography curriculum (Walford, 2000; Rawling, 2001). For some, the compulsory orders of the National Curriculum renewed the focus on

the teaching of place. Marsden argues that place was rightly returned to a central position in the curriculum:

It has made explicit geography's distinctiveness, in returning place to centre stage, focusing on detailed localities and other scales of place, and on spatial studies into which geographical themes and skills must be permeated, thus linking physical and human aspects of the subject through places in an authentically geographical way. (Marsden, 1996, p11)

The first draft, of the 1991 curriculum specified a choice of three locations to study from twelve options. One from Less Economically Developed Countries (LEDCs); one from the European choices of France, Germany, Italy and Spain; and one from the USA, Japan or the former USSR (Roberts, 2006). As a new head of a geography department in the early 1990s, I can remember the effect that this prescriptive choice had on our teaching. We focused on Kenya, Italy, Japan and the USA and although our evidence was small-scale and anecdotal, we experienced considerable concerns about the skewed and narrowed view of specific places and the world in general that these 'teaching choices' prescribed for us. Though we tried to diversify our teaching beyond the fairly dry and uninspiring whole-class texts recommended for the National Curriculum, this regimentation was detrimental to developing students' wider understanding of the uniqueness and diversity of place.

Many geography educators continued to voice similar concerns over the distorted world image that the National Curriculum encouraged in its earliest guise. In his analysis of the influence of Geography National Curriculum textbooks, Hopkin (2001) revealed the disturbingly truncated experience of place presented to students. His study highlights a worldview which directed their gaze firmly on the developed North and one that was mainly UK- centric. The 1999 revision encouraged an even narrower selection of place. Hopkin (2001) is right when he states:

Greater flexibility in the G.N.C. to select places seems unlikely, in itself, to have a notable short-term effect; for although there is currently significant choice, teachers and authors are locked into investigating quite a limited range of places. (Hopkin, 2001, p 64)

By giving teachers the choice to study just two non-specified countries an even more limited number of places were subsequently studied. Roberts (2006) later identified the most popular of these

narrowed choices as the 'big four': Italy and/or Japan as a More Economically Developed Country (MEDC) and either Brazil or Kenya as their Less Economically Developed Country (LEDC). She also concluded that whilst the peculiar world thus constructed and presented to students was influenced by amongst other things: geographical content, teachers experience and students' experiences and preferences, the overriding factor was the choice of GNC textbooks purchased.

The QCA Key Stage 3 review and consultation (QCA, 2005) and publication of the draft GCSE subject criteria for geography (2007) and the new GCE specifications for 2008 collectively represented a major watershed for school geography and more specifically a return to place as a central concept. Subsequent developments, particularly the advent of the new concept-led Geography National Curriculum (2008) and new specifications at A level and GCSE re-focused attention on how geography knowledge is created in schools (Lambert, 2011). At the same time, criticisms of school geography as being both 'un-engaging' and 'lacking relevance' to the lives of young people continued to linger and challenge the subjects' attempts to re-kindle its kudos. In particular, its newly-emergent curricular landscape was silhouetted by the rather more ominous backdrop of the subject's continued marginalisation in primary schools; its on-going decline in numbers at GCSE and A Level and what some perceived as a gradual but seemingly unshakable intellectual dislocation from university geography. From a more optimistic viewpoint, acknowledgement of sanguine signs that recent curriculum change was starting to give teachers a freer rein to reshape school geography was vitally important.

In its geography manifesto: *A Different View* (2009), the Geographical Association encouraged teachers to invest their specialist knowledge, skills, expertise and energy into stimulating student interests and needs. The type of young people's geography education illustrated in the manifesto was dynamic and challenging, inspiring a living geography for change in a changing world. Young people were seen as a pivotal in shaping the living geography promoted within *A Different View* which included geographical understanding of alternative futures. The 'manifesto' certainly set out a strong argument that almost five years later would appear to have been a crucial time for geography educators to be critically aware of the significance of decisions made about directions to be taken in school geography. As ever, this was a complex and challenging prospect for a number of reasons: Firstly, devolvement of more curriculum responsibility to teachers was not necessarily enough to re-

vitalise school geography unless their engagement with the process of 'making geography knowledge' was both more critically and broadly educative.

When the current Conservative- Liberal Democrat coalition government came into power in 2010 they brought about another round of review and potential changes in school education. The 2010 White Paper on Education (DfE, 2010) gave the first indication of a marked shift further towards more prescribed factual core knowledge. With its publication there was no doubt that school geography had reached another significant crossroads in its evolution. The recent publication of the new Geography National Curriculum (due to be taught in schools from September 2014) reveals the full extent of an increased emphasis on prescribed content. At Key Stage 3 pupils will be required to build on their locational knowledge and deepen their spatial awareness of world countries. With regards to place knowledge pupils will be required to use 'place-based exemplars at a variety of different scales' (DFE, 2013 p 202). In connection with developing pupils' relational thinking, the new curriculum stipulates the requirement for them understand how geographical processes interact to produce diverse landscapes. With specific regards to GIS, pupils will be expected to use these to 'view, analyse and interpret places' (DFE, 2013, 202).

Though the empirical stages of this research were carried out some considerable time before the publication of the new 2014 curriculum orders, there is considerable evidence discussed in chapters 4, 5 and 6 which can inform teachers' choices about how to apply the use of GIS to fulfil those requirements. Chapters 7 and 8 discuss these findings in detail.

In the first part of this chapter I have reviewed concepts of place, place and relational knowledge and the nature of place in school geography education.



## Part 2 GIS

### 2.4 The nature of GIS

In order to fully understand the nature of the geo-technologies used in the empirical stages of the research and the associated implications of using these to teach and learn about place in school geography education it is important to establish the precise nature of GIS in terms of how it functions. With this purpose in mind, this second part of the review gives an overview of the nature of GIS used in schools. Whilst it provides insights into the key principles underpinning GIS per se, the overview is simplified and designed to set the scene directly for the school-based empirical studies that follow. A more in-depth analysis of concepts and applications of GIS can be usefully found elsewhere (Longley, et al; 2001; Harvey, 2008). The discussion that follows begins with an overview of the key principles of GIS which are relevant to the core focus of the thesis, namely constructing and interpreting relational place knowledge through GIS. The review begins by considering those key principles and then discusses the nature of geographical representation and constructing geographical knowledge in GIS; the nature of new geospatial technologies, the field of critical GIS and the relationship between GIS and relational place knowledge. The review concludes by considering more specifically the nature of GIS in school geography education.

Whichever definition of GIS one chooses to consider, the common denominator in all is that spatial thinking lies at the heart of conventional GIS. GIS bring layers of information together, by overlaying data. Overlay is the principle method through which spatial analysis occurs (Schuurman, 2004).

Spatial science in the 1960s and 70s focused on interpreting human activity through a scientific view of geographical space (Cloke et al, 2006). Longley et al; (2001) provide an encompassing definition of GIS, when they state:

Many definitions of GIS have been suggested over the years, and none of them is entirely satisfactory, though many suggest more than a technology. Today, the label GIS is attached to many things: amongst them, a software product that one can buy from a vendor to carry out certain well-defined functions; digital representations of the world in the form of datasets, a community of people who use and perhaps advocate the use of these tools for various

purposes; and the activity of using GIS to solve problems or advance science. (Longley et al; 2001, p 10)

There are a number of significant principles common to all GIS which will help to contextualise the part of the discussions which follows on spatial thinking, geographical representation, critical GIS and relational knowledge in GIS. This broader grounding will also help to set the scene for the more specific discussion which concludes the chapter and serves to bring our focus onto the empirical stages of the research, namely, about the role of GIS in school geography education.

Early versions of GIS were created to identify potential land use, to map populations to support census records, to develop commercial interests in a cartographic industry that was beginning to grow exponentially at that time. For often more controversial reasons, computerised GIS were being rapidly assimilated in military surveillance and weapon deployment. GIS at that time became the cornerstone of the global geospatial industry that still exists today – one built on a professional reputation as a rigorous, scientific technology that specialised in spatial science tools that could identify, locate and map geographical phenomena.

Modern desktop GIS had been developing apace since the early 1980s at the same time as prices of computer hardware began to fall dramatically. These two related factors contributed to the rapid diversification of a commercial market for GIS. The fledgling GIS technology created by CGIS to identify potential land uses in the 1960s began to appear in use to display census records, mapping agencies and a wide range of military applications including remote sensing and the Global Positioning System (Longley et al; 2001). GIS became the cornerstone of this geospatial industry. The proliferation of the use of spatial tools to carry out key functions in identifying, locating and mapping geographical phenomena had begun. GIS began to gain the reputation as a rigorous, scientific technical application which could be used to solve 'geographical problems' that it still maintains amongst its advocates today.

Once data has been chosen, the ways in which data about a place is displayed through geospatial technologies varies also vary depending on whether the system being used is a conventional GIS such as ArcGIS (the GIS used in the research) , a virtual globe such as Google Earth or an application that can combine both (for example ArcGIS online). All geospatial technologies focus on location as a prime element of the data that they are able to store, manipulate and transform.

Georeferencing, the process by which data is given a locational reference is fundamental within a geographic information system:

Knowing where something is located, how its location influences its characteristics, and how its location influences relationships with other phenomena is the foundation of geographic thinking. (Malone et al; 2005 p7)

## 2.5 Geographical representation in GIS

In this part of the review, the emphasis is placed first on the nature of geographical representation in a conventional GIS. The representation of geographical information in other forms of geospatial technologies such as virtual globes is considered later in the chapter (see section 2.7).

The nature of representation has always been fundamental in geography. 'Writing the earth' has become synonymous with what geographers do. In particular geography is expressed through maps. In GIS, preparing data to be represented in a digital form is the key precursor to displaying and analysing spatial information. Digital representation refers to the technical means through which all information is displayed in a computer. All data, including text, images and geographical information is identified by a code which a computer can recognise and manipulate. This process allows information to then be viewed in a meaningful way. All computer data, including text, images and geographical information is identified by a binary code which can be captured, stored and manipulated digitally. It is the simplicity of this binary coding which has contributed so to the success of digital technology. In a GIS, this allows a user to interact with a geographical representation in ways which were never possible with for example paper maps - text, graphics and maps become manipulable (Longley et al; 2001). However, modern computers use only binary numbers (0 and 1) to code information:

'Computers represent phenomena as binary digits. Every item of useful information about the Earth's surface is ultimately reduced by a GIS to some combination of 0s and 1s.'

(Longley et al; 2001, p.61)

In the case of digital geographical representations, all can only be partial representations of reality because of the limitations of computation. As Longley et al; (2001) also argue:

The world is infinitely complex, but computer systems are finite. Representation is all about the choices that are made in capturing knowledge about the world.

(Longley et al; 2001, p 65)

In conventional GIS, one of the key aspects of how geography is represented depends on the process of data modelling. In the same way that paper maps are creations of their makers, digital GI is very much the product of the constructs of the data model used to project it. There are two main ways in which 'real-world phenomena' are modelled in a conventional GIS: as vector or raster-based systems. These two systems interpret binary digital representation of data differently:

There is recognition in GIS that different *data models* produce dissimilar ontologies for what are the same objects on the ground. Thus the way data are structured inside the computer has a profound impact on how entities appear on the screen, and more importantly, the results of analysis.

(Schuurman, 2004, p 32)

The term 'ontology' is used specifically in GIS to describe the clearly defined objects and relationships between them digitally coded into either a vector or a raster system. The world in a raster data model is displayed as a series of grid cells or pixels. Usually, the grid is divided into layers of information or *attributes*, for example landscape type or population density. Each cell in a raster view is assigned an 'attribute value'. The 'value' of each cell is calculated as an average which is normally measured by taking the 'value' at the centre of each cell. This is very significant when we consider how place is represented in GIS, because the very process by which geographical information is entered into the system is via a process where data is homogenized across a whole (normally a 30m) pixel. The data that is geo-referenced for that cell is an average. Representation of place in the vector data model closely resembles traditional map-making: features are represented as points, lines and areas. In a vector GIS, all data originates as point data; lines are connected points; areas are conjoined series of points or *vertices* forming straight-edged representations known as *polygons*. Both vector and raster data models are described as *field view models*, where information is displayed as a continuous surface:

The field view represents the real world as a finite number of variables, each one defined at every possible position.

(Longley et al; 2001, p 69)

Both vector and raster data models are also described as *layer models* because layers of different data can be compared in either model. For example, comparing landscape type and population density layers or creating overlays of each has become a seminal feature of all GIS. An alternative data view is the *discrete object view*:

The discrete object view represents the world as objects with well-defined boundaries in empty space.

(Longley et al; 2001, p 67)

Discrete objects in GIS can be easily categorized into groups, for example, well-defined physical features such as lakes or human features such as buildings. All data about a place is categorised in a GIS. Data is categorised into four main types: nominal, ordinal, interval and cyclical data. Nominal data includes simple locational information, e.g. a place name. Ordinal data is ordered data, for example class of land use. Interval data includes information which can be scaled, for example temperature. Cyclical data is directional data and is represented directionally e.g. latitude and longitude.

Despite the physical limitations of representing geographical phenomena through GIS, it remains a powerful medium for making connections between sets of data in related data bases. As Schuurman argues:

The power of GIS emerges partly from its capacity to make visual spatial relationships, and to picture spatial objects in a way that allows users to interpret them. (Schuurman, 2004, p 12)

## 2.6 Constructing geographical knowledge in GIS

As the introduction to this part of the chapter has already established, spatial thinking lies at the core of GIS. In their report: 'Learning to think Spatially' (2006) the US National Research Council presents the argument that space as represented in GIS can provide a conceptual and analytical framework within which geographical data can be represented and interpreted. The type of spatial thinking advocated by NRC is underpinned by understanding the world through very specific digital spatial structures. Golledge and Stimson (1997), both GIS specialists and behavioural geographers, identify three significant elements of this kind of spatial thinking which are widely referred to in the spatial literature. These are:

- spatial visualisation
- spatial orientation
- spatial relations

According to Golledge and Stimson, spatial visualisation is the cumulative effect of the processes by which an individual perceives their immediate and more distant surroundings. Spatial orientation focuses on an individual's abilities to place themselves within space and to navigate around it. Spatial relations include the ability to recognize the significance of places and to make informed judgements about connections between them. Each of these elements of spatial thinking can be internalized by an individual as components of their unique spatial cognition. Many definitions of spatial cognition exist in the literature. Hart and Moore (1973) define it thus:

Spatial cognition is the knowledge and internal cognitive representation of the structure, entities, and relations of space; in other words, the internalized reflection and reconstruction of space in thought. (Hart and Moore, 1973, p 248)

Spatial thinking both within and beyond GIS often depends on understanding and addressing the concept of scale. The literature reveals a general acceptance of the sub-division of space into small- and large-scale (Downs and Stea, 1977; Montello, 1993; Freundschuh and Egenhofer, 1997; Kitchin and Blades, 2002). Tversky, Morrison, Franklin and Bryant (1999) categorize small-scale spaces as space surrounding the body and the space of the body. Large-scale spaces are spaces which require movement within them to experience them in their entirety. Large-scale spaces include our

immediate (environmental) surroundings and larger- scale geographical space beyond. Large-scale spaces cannot be viewed from one vantage point. When we interact with large-scale spaces we must integrate information from a number of different views or sources. As part of this assimilation, we use both our prior learning about similar environments and our immediate if somewhat partial view (Mark, Freksa, Hirtle, Lloyd and Tversky, 1999).

Freundschuh and Egenhofer (1997) sub-divide large-scale space into environmental and geographical spaces. Environmental spaces are non-manipulable large-scale spaces which require movement around them to experience their entirety. Examples of environmental spaces are buildings, neighbourhoods and cities. The vast majority of cognitive mapping research has focused on environmental spaces (Siegel and White, 1975; Uttal, 2000). Geographical spaces are much larger-scale non-manipulable spaces. Like environmental spaces, geographical spaces cannot be experienced in their entirety without movement around them. Appropriately, Tversky, Morrison, Franklin and Bryant (1999) describe geographical space as the 'space of navigation'. Examples of geographical spaces are regions, countries and continents ( Kitchin and Blades, 2002). Realistically, because of the enormous scale of geographical spaces, they are rarely completely experienced by an individual.

The same cannot quite be said for represented or 'map space' (Freundschuh and Egenhofer, 1997). For many centuries, humans have at least partially portrayed geographical space through maps. Although the experience of cartographic geographical space cartographically may be indirect and incomplete they are manipulable. Spatial information tools such as geographic information systems and earth viewers can represent very large scale geographical spaces and elements within them whilst allowing users to manipulate them as though they were small scale.

Although human spatial cognition seems to operate differently in small- and large- scale spaces, maps and GIS enable us to interact with large-scale spaces as though they were small-scale or manipulable.

(Freundschuh and Egenhofer, 1997, p362)

This is a unique element of GIS technology – the further significance of which I return to in the discussion of findings (Chapter 7)

**Fig 2.2** Classification of GIS geography knowledge (after Mark, 1993)

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	CONFIGURATIONAL KNOWLEDGE
PLACE (NAMES), LOCATION, SPACES, DISTANCE, SCALE, VOCABULARIES ABOUT PLACE (E.G. REGION, DISASTER ZONE, SETTLEMENT INFRASTRUCTURE)	→GIS NAVIGATIONAL SKILLS→ <ul style="list-style-type: none"> <li>• Orientate</li> <li>• Pan</li> <li>• Zoom</li> <li>• Link</li> <li>• Co-ordinate</li> <li>• GPS</li> </ul>	RECOGNISING & INTERPRETING GEOGRAPHICAL PATTERNS MAPPING GEOGRAPHICAL PATTERNS <ul style="list-style-type: none"> <li>• Display</li> <li>• Measure</li> <li>• Attribute</li> <li>• Tabulate</li> <li>• Overlay</li> <li>• Input</li> <li>• Edit</li> <li>• Symbolize</li> <li>• Aggregate</li> <li>• Classify</li> </ul> ANALYSIS <ul style="list-style-type: none"> <li>• Query</li> <li>• Interpolate</li> <li>• Statistical</li> </ul>



Figure 2.2 classifies rather more precisely, exactly how the construction and use of geographical knowledge may be explored with GIS according to one particular classification devised by Mark (1993). Mark classifies the type of knowledge produced through GIS geographically. He identifies three inter-related categories: *declarative*, *procedural* and *configurational* geographical knowledge. According to Mark's classification, declarative geographical knowledge is factual knowledge *about* geographical space. This may include facts about for example, names of locations and landforms.

Declarative geographical knowledge may form the basis of the knowledge that individuals acquire, but, in reality, procedural and configurational transformation of that knowledge brings deeper geographical understanding. Mark suggests that procedural geographical knowledge includes information which allows us to navigate *in* geographical space. Using the basic elements of declarative geographical knowledge we act on information assimilated about landmarks and routes as we find our way from place-to-place. Mark defines configurational geographical knowledge as knowledge that allows us to formulate map-like information. Using declarative knowledge as a base and, perhaps, direct procedural geographical knowledge, we configure pattern, direction, orientation and hierarchy. At a simple level, using Beck's London Underground Map (Beck, 1933) illustrates how we mentally represent this type of configurational knowledge. The colour-coded topology of the map allows us to focus only on essential information: routes, line directions and 'anchor points' such as station interchanges. As a result, geographical knowledge is transformed into a new at least simplistically relational form. An emphasis on relational geographical knowledge involves the more sophisticated level of geographical thinking and reasoning that I have already suggested. These include many potentialities: understanding geographical difference; relations between places; broader interpretation of human-environment interaction at a variety of scales; deepening spatial comprehension; enhancing geography-rich spatial decision-making to name but a few. Whilst Figure 1 can be used to classify the type of geographical knowledge that is constructed in a lesson supported by GIS, it can also be used as a basis for thinking about the opportunities and limitations for thinking relationally through GIS.

Whilst, the discussion in this section has focussed on the broad principles underpinning GIS which are relevant to the core focus of this thesis, namely constructing and interpreting relational place knowledge through GIS, it has also considered the nature of geographical representation through GIS per se.

Equally important in the context of the focus of this thesis on the use of GIS and related technologies in the contemporary school geography classroom is the nature of new geospatial technologies and how these may contribute to future trends in GIS. It is to the latter that this discussion now turns.

## 2.7 New geospatial technologies

With this broader consideration of the nature of new and future developments in GIS in mind, Elwood (2008) discusses the major changes that have occurred in terms of developments in new geospatial technologies, particularly earth viewers such as Google Earth. This has included a major change in the way that some geospatial data can be accessed. As Elwood discusses:

In the world of geospatial technologies, change is afoot. In the past five years, we have seen the emergence of a wide array of new technologies that enable an ever-expanding range of individuals and social groups to create and disseminate maps and spatial data.

(Elwood, 2008, p 256)

As Elwood points out, these online applications share some commonality with traditional GIS in terms of digital storage; retrieval and visualisation, there are actually few other similarities. This analysis is poignant to this discussion about teaching and learning about place through geospatial technologies because there is an onus on teachers having some level of technical understanding of the implications of the difficulties of representing heterogeneity in GIS. In terms of public geographies, there is considerable debate required by teachers for how the information 'mashed-up' in these APIs can be used in classrooms if at all. The very characteristics of these new data that are deemed so promising are at the same time difficult challenges in GIScience. Integrating heterogeneous data, representing qualitative spatial expressions, and incorporating the dynamic meanings of data as they are transformed in use are all extremely complicated in a digital environment.

Elwood (2008) addresses the plethora of complexity that new 'spatial technologies' offer. She argues that GIS are more than just the sum of their technological capacity. Instead, she contends that they are:

Digital systems for storing and representing spatial information; they are complex arrays of social and political practices; *and* they are ways of knowing and making knowledge.  
(Elwood, 2008, p 257)

The burgeoning of new web-based technologies over the last five years has considerably affected the argument about 'making worlds' in GIS in geography classrooms. Since its inception, digital place through virtual globes has become increasingly socially significant and omnipresent. The idea of GIS satellite imagery as powerfully affecting *and* affective both visually and conceptually is an increasingly important one to explore. In the past, satellite imagery in particular was mainly used in the military domain to locate targets, to monitor land-use change and in planning. More recently, however, these types of GIS have moved at least partly into the public domain to the extent that virtual globe atlases are becoming the 'default meta-geography of the media.' As Dodge and Perkins (2009) contend:

That sense of being 'within' is greatly enhanced by the visualizing practices of more advanced geographical information systems and interactive telecommunication systems, which at once set the world at a distance- accessed from a platform, seen through a window, displayed on a screen – and yet also promise to place the spectator in motion inside the spectacle. This is a radicalised vision of modernity, one that gives a wholly new dimension to Marx's image of a world in which 'all that is solid melts into air.' And to some thinkers it heralds the very end of modernity.(Dodge and Perkins, 2009, p 497)

New Web 2.0 applications of virtual globes, many of which rely on application programming interfaces (APIs) are geared to support multi-media representations. Some advocates of GIS consider 'geo-visualisation' as a concept to be the 'fourth R' that is, as important as reading, writing and arithmetic (Goodchild, 2006). This is interesting in the current burgeoning of geospatial technologies. Goodchild (2008) makes an important distinction between the ways in which geobrowsers in particular are increasingly being used. He argues:

People are finding uses for the geobrowsers<sup>12</sup> that are very different from typical GIS applications. They have none of the analytic modelling, and inferential power of GIS, and

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<sup>12</sup> Though geobrowsers are considered easy to use (Goodchild, 2008), there is an emphasis in them on visualisation as opposed to the analysis that lies at the heart of GIS. With this visualisation comes the

while oriented to visualisation are nevertheless very limited in what can be visualised, because of their insistence on content that is inherently visual. In other ways, however, the uses of geobrowsers go well beyond those of GIS, reaching into a broad and rich domain of spatial concepts that can be very powerful aids to understanding and insight. (Goodchild, 2008, p 11)

Current debates suggest that thoughtful use of such technologies have much to offer in promoting geographical understanding. The use of virtual globes is a new way of looking at the world, one in which it is important to consider the technology behind it and the reasons for the production of the geographical information that is visible or not visible within it. In a similar way, virtual globes such as Google Earth have the functionality to upload 'geographical information' (as kml files) into the virtual globe itself. Some may even argue that this is a new quite different type of geographical knowledge which has not yet been categorised, a kind of 'Neogeography' (Turner, 2006). This type of participatory GIS (for some have defined it thus) – this means of 'annotating the planet' (Udell, 2005) requires careful consideration by educators as this research has indicated. If we are to let students loose on virtual worlds we need to be aware of the origin, validity and value of the various 'wikis', podcasts, vidcasts and other 'geotags' and mash-ups that we may be justifying and validating by facilitating their access to them. Some may argue that this more emancipatory, 'bottom-up approach to using GIS and virtual globes opens up a world of opportunities for geography education. However, caution about the quality of 'geographical information' we may wittingly or unwittingly sanction seems prudent.

The increased availability and the easier technical use of technology such as Google Earth raise important questions about how the information within is created. Dodge and Perkins (2009) contend that:

Different theoretical approaches may be deployed to interrogate the significance of these powerfully affective visual technologies, and indeed it can be argued that the democratisation

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possibility of 'manipulating a virtual body' )of the earth in a way which before the advent of Google Earth in 2005, was only possible through quite complex, technical GIS procedures (Goodchild, 2008).

of satellite image accessibility is itself part of a significant epistemological shift.(Dodge and Perkins, 2009, p 498)

In their consideration of the political implications of how Google Earth and satellite imagery was used in New Orleans after Hurricane Katrina, Crutcher and Zook, (2009) , examined the 'mapped cyberscape' (Dodge and Perkins, 2009, p 499) and offered an analysis of the role of imagery and the use of Google Earth placemarks in a series of mash-ups posted online. Their analysis offers a fascinating insight into the nature of the racial composition of an area and the 'post-Katrina cyberscape in Google Earth.' In a similar way, the 'Digiplace' that Zook and Graham (2007) describe is invisible for those without the economic means of access or the cognitive and technical capacities to access it. Zook and Graham (2007) argue:

' DigiPlace represents the situatedness of discrete individuals straddling virtual and physical realities, rather than any sort of shared, objective, and fixed reality.'  
(Zook and Graham, 2007, p8)

In her examination of the use of Google Earth in school education: *Digging into Google Earth: An analysis of 'Crisis in Darfur*, Parks (2009) argues that treating earth viewers such as Google earth as a field in which questions about the world can be initiated and answered is one particular way of using GIS effectively. Parks' argument also focuses on this idea of interaction between the use of digital technologies and the political and social processes at work in the world. She contends:

Armed with such information, world citizens might be more apt to pressure their governments to formulate proactive as opposed to reactive foreign policies, to understand world conflicts as more than the primitivism or pathology of tribal warfare, and to help push the historical forces and power hierarchies that shape the planet into bold relief.  
(Parks, 2009, p 544)

Crutcher and Zook (2009) argue that the use of satellite imagery with online user comments can (as quoted in Dodge and Perkins, 2009) : 'create highly differentiated connections between places and cyberspace.' In a similar argument, Parks (2009) discusses the benefits and disadvantages of representation of 'real events' through GIS. In her examination of 'Crisis in Darfur' she describes the

illusion (my interpretation) of the idea that perhaps the closer 'zoomed view' in Google Earth brings with it a deeper understanding. But does it? She also considers what the 'gods eye view' through satellite imagery may also encourage in terms of interpretation and understanding. She argues:

The structural interplays between the far and near that undergird Google Earth's Crisis in Darfur project are helpful in that they represent the potential to refigure key terms of humanitarianism. The iconographies of suffering are not reduced merely to images of people, but are placed in dynamic alternations with satellite images and graphics that emphasize the territorial and the geopolitical.

(Parks, 2009, p 544)

In a similar way, but in a discussion about digital maps in: 'Plotting the personal: Global Positioning Satellites and interactive media' (2001), Lisa Parks also contests the meanings of place knowledge created through geospatial technologies. For example, in her consideration of GPS tracking technology, she argues that there is a fusion between the personal experience and the social landscapes 'portrayed' and accessed through GIS. In a later examination : Digging into Google Earth : An analysis of 'Crisis in Darfur' (2009), Parks explores the implications of what she views as stereotyped views of Africa presented through Google Earth and the 'disaster capitalism' (term coined by Naomi Klein). She contends: In short, Google earth is not 'a view from nowhere' – it is the view from a company with enormous visual capital.(Parks, 2009, p 542)

Kingsbury and Jones (2009) support the idea that GIS introduces digital worlds that are also only 'knowable' in a perspectival way i.e. they are very much open to individual interpretation despite some superficial evidence to the contrary as discussed below. In a rather impassioned view, they argue:

A virtual globe composed of surveyed panoramas, sober rationalization, dystopic control, and transparent order – or, even, as a tool for participation and empowerment – we undersell its capacities as an alluring digital peep-box, an uncertain orb spangled with vertiginous paranoia, frenzied navigation, jubilatory dissolution, and intoxicating giddiness.

(Kingsbury and Jones, 2009, p 502)

Whilst Kingsbury and Jones's analysis is perhaps a more colourful critique of digital portals such as Google Earth, it does emphasize a need for the further development of a discourse about the new spaces of cultural politics that is continuing to open up through this new type of web-based GIS.

Kingsbury and Jones (2009) analyse a series of exchanges about the tools used through Google Earth to 'observe' the crisis in Darfur. They argue:

Google Earth's profane illuminations, wherein objects gaze back at us as we disappear (see Doel, 2006) or get lost in meanings that are at once excessive and insufficient, demands attending to new geometries of power in scopic regimes.

(Kingsbury and Jones, 2009, p 508)

There is an intoxicating element to this new found ability to interact with large scale geographic space through GIS. Kingsbury and Jones describe this (2009) as 'surfing under the influence of Google Earth.' They make a number of claims about Google Earth's role as a 'digital peep-box', its *failure* to 'reveal a visible and legible world' and its non-Foucauldian role as panopticon (Kingsbury and Jones, 2009, p505). In discussing Lammermen and Bergsma's 'peepbox concept' (2006), Kingsbury and Jones (2009) contend that:

The peep-box boundary equates to Google Earth's 3D geo-referenced scene, the peep-box faces stand in for Google Earth's digital pictures and bit-maps, the cellophane represents Google Earth's atmospheric lights' and 'clear blue skies', while the peephole mimics the interface between users and the 3D scene'.

(Kingsbury and Jones, 2009, p 505)

There is also the question of the partisan nature of the ways in which Google censors some material uploaded into Earth and Maps and not other material, despite the often 'open appearance of debate about this on the Internet. Zook and Graham (2007) argue that Google Earth's DigiPlace is some considerable distance down the road in becoming the *de facto* digital globe. They contend that there: 'remains much to be done in understanding how new lived spaces are influenced by the intersections between culture, code and place'. (Zook and Graham, 2007, p 18).

The ways in which new cultural spaces are opening up on the web raise other questions both educational and ethical. In her critique of the 'Crisis in Darfur database', Parks reminds us of Vaidhyathan's description of the 'Googlication of everything' (2009). She focuses on the idea of interaction between the use of digital technologies and the political and social processes at work in the world. I argue that this is particularly poignant in the geography classroom where geography through education can utilize these types of technology to develop knowledge and understanding further.

In connection with the hegemonies of GIS and maps as 'partisan place,' there is also the issue of the way in which this technology is being used as a tool of representation. The nature of the tools of construction within digital geographies become explicit when looking at the types of mosaiced pixels shown in satellite imagery. Dodge and Perkins make some important observations about the ramifications of these when they contend that:

'Perhaps the biggest 'lie' of this seamless imagery is that it is constructed out of tiles from different times, which are mosaiced together to create a wholly artificial view devoid of cloud cover. Also as much imagery is captured in periods when skies are clear, and when vegetation growth is maximised and visually prominent, the result often obscures the built environment, and this diminishes the presence of people in the landscape. (Dodge and Perkins, 2009, p 498)

In a discussion that pre-dates modern use of the virtual globes, Gelernter (1992) considered making worlds in digital space and the role of the individual as participant in a new visual environment. He emphasised a new kind of perspective on place, one which is partly subjective and partly simulacra. He stated:

A mirror world is some huge institutions moving, true-to-life mirror image trapped inside a computer-where you can see and grasp it whole. The thick, dense sub-world that encompasses you is *also* now an object in your hands. A brand new equilibrium is born. (Gelernter, 1992, p 3)



Here are opportunities for considering place as *subjective* and *dynamic* in ways that were not as feasible through traditional GIS. Kingsbury and Jones (2009) support the idea that GIS introduces digital worlds that are also only 'knowable' in a perspectival way i.e. they are very much open to individual interpretation despite some superficial evidence to the contrary as discussed below. This is a very different take on merely considering coming to know place, It is, I am arguing, a new dimension of spatial politics. Let's explore this idea a little further. If 'DigiPlace' is not permanent or fixed space but is shaped by people places and processes in a way that is not only changing space within GIS but also material space outside then this has ramifications for knowing place, per se. Dodge and Perkins also argue that :

The visual virility and earthly representational richness of these images *can* also make recognition and interpretation of space much harder. The viewer may actually understand less of the structure of the place without the classification and clarity offered up by the professional eye of the cartographer. (Dodge and Perkins, 2009, p 498)

This is, I suspect, one of the 'challenges of space' (Massey, 2005) with GIS and why in geography and geography education, the making of place still matters. This depends to a considerable degree, as the data from this research and elsewhere suggests, on the choices made about how to conceptualise place through GIS. It is important to note here that the metadata relating to GIS albeit map or satellite imagery metadata about data capture and resolution, for example, is usually hidden way below the surface of something like an earth viewer. To the untrained end user, this metadata is not usually accessible; for teachers using GIS this is ethically and educationally significant. Parks (2009) calls for caution regarding the potentialities of earth viewers such as Google Earth. She argues that:

While Google Earth presents exciting new possibilities for integrating and accessing documents and audiovisual materials and providing them in geo-referenced fashion, information interventions such as Crisis in Darfur need to be discussed and evaluated carefully.

(Parks, 2009, p 544)

Following on from this discussion on new developments in GIS, the next section develops the questioning approach developing here by reviewing more fully the field of critical GIS.

## 2.8 Critical GIS

During the two decades since its inception and before the disquiet that ensued between pro and anti – GIS camps in the 1990s, the GIS academic community had been busy. Although GIS applications had begun to surface in the corridors of higher geography education without much fanfare, their arrival could not go unquestioned indefinitely. In an early critical discussion of GIScience Mercer (1984) argued that so much had the elevating of the rational above the abstract progressed ( Mercer was actually alluding to Whitehead's famous critique on scientific knowledge ), contending that a predictable, accountable and codified GIS view was part of the accepted and 'official reality.' Mercer makes an interesting analogy when he argues:

Geographers have recently demonstrated considerable interest in the construction of 'territorial social indicators' relating to health care. Travel distances to hospitals and doctors are computed in order simplistically to identify geographical regions of health care 'need' I would argue that such an approach is misplaced because it fails to address itself to the logically prior, and much more important question: 'What causes people to be unhealthy in the first place?' (Mercer, 1984, p 190)

In the early 1990s friction became palpable as mainly non-technical human geographers began to question GIS on a number of different levels. Despite the fact that the first incarnation of GIS was developed in the form of the Canada Geographic Information System (CGIS) in the mid- 1960s, disquiet regarding the philosophical foundations of GIS only began to be widely debated by geographers in the early 1990s. Some critical (mainly human) geographers, who until that point had seemed to be quite content about the development of this new technology began to air caution about the proliferation of GIS technologies and the implications of this. Their concerns were manifold, but in particular, they feared what they saw as a retrograde step back to the quantitative/scientific ways of thinking geographically that was dominant during the emergence of spatial science in the 1960s and 1970s. Not only this, they were beginning to become more aware of the social implications of mass-produced geographical information (Schuurman, 2000).

The main critique of GIS has always been that conventional GIS cannot adequately represent the world through its narrow parameters. In particular, the view of the world portrayed as an independent Cartesian grid system through conventional GIS on which social processes of geography are located. Proponents argued that human geography in particular was far too complex and varied a discipline to be framed and understood through the positivist science of conventional GIS. This was strong criticism, particular in relation to the idea that concepts of space (both geometric and relative) and the spatial reasoning most often resulting from using GIS can narrow worldviews.

The renewed stirring of unease in the 1990s was only the start of a protracted spat between advocates of GIS and those rather cautious of its roots and implications. By the mid-1990s, the criticisms which began to surface and develop were not just based on suspicion or lack of technical knowledge about computing. Mainly, concerns were voiced on the basis of two over-arching criticisms: the positivist origins of GIS; and the possibilities of questionable ethics behind its intentions (Schuurman, 2000; Sui, 1994).

The focus of critics of GIS on more philosophical concerns was to prove the most notable at that time. Dissatisfaction with GIS settled for academics on its potential to limit ways in which individual users could think geographically (Lake, 1993; Sui, 1994). For some, the 'language of GIS' with its emphasis on spatial and attribute data seemed to shape a kind of sheer, aesthetically-pleasing representation where potentially 'fuzzy social knowledge' was rejected in favour of the smooth clean lines of vectors and polygons. In summary, then, the dangers levelled by critics were seen to stem from the inherently positivist nature of GIS which was blamed for producing a technology which could only quantify and not qualify. Some argued that unquantifiable social phenomena could not be accommodated in a geographical information system (Sui, 2004). As Schuurman (2000) identifies, critics' opinions were encapsulated by a strong view that GIS was: 'by implication, a means of limiting the proliferation of epistemologies in geography' (Schuurman, 2000, p 580).

The polemic which continued to build during the early to mid-1990s was debated more fully in 1995 with the publication of *Ground Truth: The Social Implications of Geographic Information Systems* edited by John Pickles. This collection of essays challenged the technology, the ways of thinking underpinning it and the many social implications of using it to construct knowledge. Whilst there can

be no argument about the coincidence of the 'birth of GIS' with the 'spatial turn' in geographical thinking in the 1960s, the belated criticism which emerged about GIS nearly three decades later was based not only around arguments about its quantitative pedigree but were also based on negative claims about its positivist origins. Coincidentally, by the mid- 1990s, often, separate to the critique debate on GIS, other human geographers were already embarked on developing the very opposite of a limited and narrowed approach to geographical thinking. The rising status of GIS in some academic geography departments coincided with the culmination of a decade of re-thinking academic geography. If GIS really did have the power to threaten the proliferation of theoretical approaches developing within the subject, this was the most damning criticism of all.

A more constructive trend within geography followed 'Ground Truth' with the development of the field of critical GIS. The latter's more progressive research agenda partially opened up a forum where advocates and sceptics debated rather more productively over the relative merits and drawbacks of GIS. Pivotal to the inception of critical GIS was the role of the US National Center for Geographic Information Analysis (NCGIA) (Schuurman, 2006). NCGIA began to direct discussion towards a fuller analysis of the social ramifications of how GIS represents people, space and environments (O'Sullivan, 2006). The epistemological debates that raged and developed as a response or indeed a reaction to the earlier quantitative revolution had matured.

Marxist, feminist and humanistic geographers had already prepared and justified their theoretical approaches to practising and delivering their own brands of geographical knowledge (Pickles, 2006). Other responses to these early critiques of GIS included Kwan's work on feminist GIS and emotional geographies (Kwan, 2002; 2007); Brown and Knopp on queer GIS (2008); alternatives to western-centric GIS (Crampton and Krygier, 2006) and works on 'democratising the technology' (Elwood, 2002; Sieber, 2007). Kwan offers a related and poignant argument for developing a wider critique of geospatial technologies (GIS) (Kwan, 2007). Her discussion forms a renegotiation of the 'meanings of GIS at the intersection of science, art, and subjectivities'. In particular, Kwan offers an imaginative analysis of the ways in which GIS can be used as a 'medium of self-expression and a means of resistance' (Kwan, 2007, p 25).

Kwan develops this idea in relation to contemporary world issues such as 'natural' disasters, globalization and international conflict in ways that are relevant to using GIS to teach about such

'issues' in geography in education. There is also an interesting parallel here with the ethics of using GIS – through connecting young people with the moral implications of using GIS, and developing their understanding of the 'subjectivities' of the knowledge produced through the social and political practices of GIS. Kwan (2006) argues:

The dominant disembodied practices of GT (geotechnologies), however, are contestable as they are largely the result of a particular understanding of science and objectivity. (Kwan, 2006, p 24)

Leszczynski (2009) provides a useful summary of recent developments in critical GIS. Her argument goes some way to moving the debate between GIScience and critical GIS forward because she emphasises that modern GIS has changed in some respects from its early version that emerged from the tenets of the quantitative revolution (Crampton, 2009). She examines the 'discursive separation' between GIScience and critical human geography, emphasising the lack of common language between the two schools of thought that often leads to a misunderstanding of each other's aims and practices. Her discussion emphasises the important role that the poststructuralist critique of GIS has played in contributing to the more ethical mapping that has emerged through critical GIS of late. Leszczynski contextualises this approach clearly offering a persuasive argument for mapping through GIS that provides a counter-view to the 'imperial cartographic conventions' of Cartesian perspectivalism. She implies an inherent responsibility for all mapping whether digital or otherwise to include opportunities for representing difference in geography. In: *Theorising with GIS*, Pavlovskaya (2006) takes this critique of GIS further, moving on from the binary opposition of quantitative GIS versus qualitative human geography to a broader critique.

One result of the many critiques of GIS has been a more socially –aware form of GIS which celebrates a broader range of geographical knowledges than the narrowly scientific ones most often associated with traditional GIS (Dunn, 2007). The most championed movement to emerge within critical GIS has been public participatory GIS (PPGIS). Though still not short of critical review by some sceptics, public participatory GIS is considered by some to be 'GIS for the people.' It embraces an approach where local issues drive the use of technology and where there is an emphasis on community involvement with GIS. Some of the projects that adopt a PPGIS approach have included urban regeneration and sustainable development e.g. the Worldfish research projects which were set

up in the Aceh province of Indonesia to tackle environmental regeneration after the 2004 South Asia Tsunami (Worldfish, 2013). In particular, PPGIS such as Worldfish differ from more traditional GIS in that they include more complex geographical information, often including indigenous geographical information. This in itself is an interesting aspect of PPGIS because it attaches importance to deep local knowledge. Dunn describes the inclusion of indigenous geographical information in the following way:

This is not technical knowledge but rather 'deep knowledge' which places cultural values on land and place, which is manifested in fuzzy, emotional and holistic terms (McCall and Minang, 2005) and which may not fit neatly into the spatially precise demands of a GIS. (Dunn, 2007, p 623)

Public participatory mapping also involves the use of emerging GIS-related technologies such as Google Earth. The Amazon Conservation Team (ACT) has used public participatory GIS to bring together indigenous geographical knowledge and GIS mapping technology (Tulloch, 2007).

In connection with this, more recently, there has been an increase in literature written about the 'hybridization' of qualitative methods in GIS and quantitative architectures (Leszczynski, 2009). The hybrid nature of this type of geographical information system contrasts with 'traditional GIS.' Whereas Euclidean GIS may focus on absolute space, the places which could be imagined from a multi-source GIS need not and may allow for a more holistic approach to place. In a sense this involves using the rigour and structure of the geometry of a GIS but complementing it with the richness of inter-related place. This could allow for some elements of space within a GIS to be quantifiable but also to bring to it the richness of more qualitative elements. The geographical thinking that might lie behind such a holistic, multi-source GIS may present geographical information in ways which seem relevant and accessible to users other than GIS specialists. In a parallel to this, consider the media coverage of the tragedy mapped the events that occurred in very distinct ways. For the first time, large-scale digital representation of the places involved appeared on our television screens and this was before the recent emergence of virtual globe technologies. In contrast, Hurricane Katrina in the August of 2005 was a much more 'virtually covered event.'

In connection with these concerns are the reductionist tendencies of GIS. In his early treatise of the ways in which GIS represents geographic information, Harvey (1997) argued about the 'teleological reductionism' and 'partial systems' of GIS. Harvey argues for an approach to using GIS that considers the holistic nature of place rather than reducing it to system components. Multi-source hybrid GIS involves using the spatial analysis of traditional GIS combined with elements of virtual globes and other emerging geospatial technologies. Of particular interest are the possible 'imagined geographies' that might result from multi-source hybrid GIS.

## 2.9 Relational geography knowledge and GIS

Conventional GIS is difficult to reconcile with some important ways of relational thinking about place. 'Traditional Cartesian GIS' places limitations on how an individual user can 'view' place. The ways in which geographical information is 'fixed' to location in GIS inevitably frames how place is represented. As a result, the Euclidean geometry of GIS appears to some to be very static. Some argue that place in GIS is very much limited by the abstracted space of its Cartesian framework of x, y and z co-ordinates. In this respect it is telling that GIS is so location orientated when I (and others) argue that location is only one restricted and georeferenced aspect of place. Some may even argue that the Cartesian and Newtonian positivist assumptions which underlie the objective world-view presented in GIS are quite dismissive of the uniqueness of place, relegating it to a kind of reduced space (Casey, 1996).

In his critique of spatial science as a whole, Gregory eloquently highlights one spatial scientist's reductionist approach to place. Discussing Peter Haggett's vision of geography as a 'distant mirror', he criticises the emphasis on site analysis at the expense of detailing even place names when studying locations (Gregory, pg 53, 1994). In my mind, such restriction is comparable to representing place within the confines of the regionalist/descriptive paradigm which reigned uncontested in school geography for over half of the twentieth century. My own vision of how GIS may contribute to school geography does not include succumbing to such a partial representation of place.

My argument is that engaging in meaningful relational thinking about place is difficult to achieve within the stark Euclidean space of GIS. It has possibly never been more pertinent or poignant for us to be thinking about the significance and relevance of relational thinking. I consider the implications of

the development of emerging geotechnologies and how these may influence how relational thinking about place GIS may develop. I build on this argument by considering the recent development of 'multi-source GIS' particularly those involving the use of virtual globe technologies. Harvey's definition of place as 'site of relations between attributes' is particularly relevant to the discussion I am developing in this chapter, particularly in connection with the role of GIS as a medium through which place knowledge can or cannot be managed or mediated. Significantly, in Cartesian GIS *place as location* is the nodal point to which *attribute data* (digital geographic information) is attached. Any kind of potentiality for relational thinking with traditional GIS is almost entirely determined by the nature of the information that is selected (or not) and placed in the system for this purpose.

I argue here that incorporating more meaningful relational thinking such as Massey's 'global sense of the local, a global sense of place' (Massey, 1991, p29) is difficult to achieve within the stark Euclidean space of a conventional GIS. As this discussion has considered before, David Harvey makes a strong case for the *undeniably relational nature of place*. He suggests that place is 'defined as the site of *relations* between attributes' (Harvey, 1996, p263).

Poststructuralist geography offers us theories which can help to support such interpretations of space and place. In his study of spatial relations in geography, Murdoch (2006) implies not only that space is generated by these kinds of interactions and interrelations. In particular, its core tenets seem to suggest that space and place be regarded as open, unfixed and engaged with each other; emanating from a multiple of processes; and most essentially, perhaps, perceived and engaged with to allow for difference and multiplicity. The way in which postmodern approaches to difference and socio-spatiality are theoretically at odds with the positivist origins of GIS is a vital element of this research - in particular, the importance of *how* geographical knowledges can be interpreted. In the light of a post-structuralist way of thinking which rejects the binaries so often presented in the positivist thinking that underlies traditional Cartesian GIS. My point here is that it is important that we challenge the thinking behind a technology and question our use of it if it closes out eyes to more open ways of thinking (relationally).

Francis Harvey identifies the potential and limits of GIS for understanding relational place through GIS. In his 1997 article: *From geographic holism to geographic information system* he states:

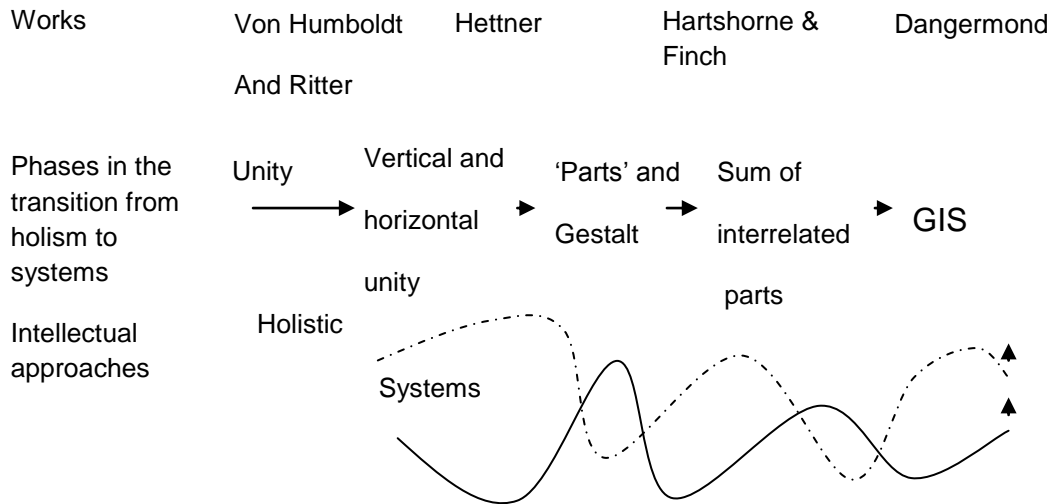
Geographic integration in GIS needs to include the complimentary aspects of holistic and systems approaches. Both the constitutive parts and mechanistic parts reflecting these



approaches are needed for understanding the uniqueness of place and interrelationships of geography. (Harvey, 1997, p 84)

Harvey discussed the duality of two very different ways of geographical thinking: holistic and systematic approaches. He examined the tensions between the complexities of deepening geographical understanding of the world and the reductionist tendencies of geographic information systems in consigning geography to layers of GIS information that has existed in geographical philosophy since von Humboldt published *Kosmos* (1845-1862). Harvey suggests that the move towards mechanistic reasoning in Western civilization has led to the burgeoning of systems-based analysis central to the development of geographical information systems (GIS). He argues that this dichotomy between holism and the systems approach has led to a fundamental contradiction in geographical thinking.

**Figure 2.3** Developments in the transition from holism to geographic information system (From Harvey, 1997)



Harvey draws our attention to the concept of vertical integration, the precursor of the GIS layer model<sup>13</sup>. The reduction of geography's complex relationships to viewing these in layers aids how a GIS works as a system but may lessen an individual's understanding of a place's interrelationships (Harvey, 1997). Harvey argues that combining a holistic and systems based approach to understanding geography through GIS is feasible and allows for better understanding of place in GIS.

Writing about the narrowness of the epistemologies underlying GIS, and the simplistic binaries of such a system, Francis Harvey presses further on the epistemologically reductionist implications of thinking geographically through GIS:

GIS layers and overlay reflect the problems and contradictions inherent in this duality. Although GIS is clearly based in the systems approach that is mechanistic, and potentially reductionist in its partiality, the core idea of geographic integration provides impetus to include holistic geographic understanding (Harvey (F), 1997, pg. 77)

Through the thesis I argue that geography teachers need to be mindful of the epistemological origins and ontological implications of GIS. If relational thinking is a both significant and relevant within a 21<sup>st</sup> century geography education, then we need to think carefully about the frameworks for thinking that are used in geographic information systems in schools.

In connection with this approach, this research specifically explores the nature of place knowledge construction in hybrid GIS. I argue that hybrid GIS can offer the types of opportunities for knowledge construction that Harvey indicated (Harvey, 1997), where the role of the geography (educator) in bringing geography subject knowledge to the forefront in their use of GIS is paramount in constructing richer place knowledge. In an earlier discussion on the nature of 'seeing places' (not dissimilar to Creswell's view on 'place as a way of understanding' that I referred to at the beginning of this chapter, Massey argues:

One way of seeing 'places' is as on the surface of maps: Samarkand is there, the United States of America (finger outlining a boundary) is here. But to escape from an imagination of space as a surface is to abandon also that view of place. If space is rather simultaneity of stories-so-far, then places are collections of those stories, articulations within the wider

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<sup>13</sup> Geographic information systems represent GI in stacked layers retrievable from the homescreen by clicking on a dropdown menu

power-geometries of space. Their character will be a product of these intersections within that wider setting, and of what is made of them. And, too, of the non-meetings-up, the disconnections and the relations not established, the exclusions. All this contributes to the specificity of place.

(Massey, 2005, p 131)

By exploring the construction of place and thinking *relationally* with GIS, this implies that using knowledge constructed in GIS to make connections about the relations and differences between places that could be more than 'map-deep' in the ways that Massey alludes to. In her discussions in 'For Space' (Massey, 2005), she considers not only the specificity of place but also develops the notion that: 'places' are criss-crossings in the wider power-geometries that constitute both themselves and 'the global' (Massey, 2005, p101). In this element of her argument, Massey contends that relational interpretations of place extend beyond simple considerations of specificity of a place or linkages between places. A fuller relational understanding of place must also take into account the 'more variegated politics; (Massey 2005, p101) connected with the construction of relational space (that make up place). Massey's thesis provides a convincing account of the ways in which different places are positioned in terms of relative political influence. In her discussion on the key phenomenon of globalisation, she highlights the contrasts between places such as London or the USA or the UK each of which hold places of considerable political powerfulness whereas other places, such as Mali and Chad occupy positions of 'relative powerlessness'. (Massey, 2005, p 101). In acknowledging the complexity of this kind of geographical landscape of place, Massey provides a way of looking at place which is more akin to the poststructuralist approach to relational thinking about space and place.

In the empirical studies in this research, I consider these kinds of understandings of space and place in a deeper, more relational sense (see Chapters 4, 5 and 6). In the discussions in Chapter 7, this involves close consideration of both the literature reviewed here and the empirical findings on constructing place knowledge through the scientific rigour of more conventional GIS, the newly-experienced neogeography of earth viewers such as Google Earth and hybrid GIS designed to combine both traditional and emerging and web-based GIS

## 2.10 GIS in school geography education

In the discussion that follows, I consider the role of GIS in school geography education with particular reference to the UK context within which this research is based and also with regards to the nature of GIS within the US school education context. It is important to establish at the outset of this section that the discussion centres on these two national educational settings for significant reasons. The first is that the empirical studies in the research are UK-based. The second being that most of the recognised literature on GIS use in schools is USA-based and therefore form significant reference points for the discussion that follows.

Before embarking on the discussion, it is also important to consider the significant contrasts between school geography education in the USA and the United Kingdom. First it is important to state that whereas the United Kingdom has a national curriculum where geography is normally taught as a discrete school subject, the USA does not (Milson and Kerski, 2012). In the United Kingdom, The strong presence of geography UK schools in comparison to the USA is the most significant contrast between the two countries. In the UK, In the UK, all students in state secondary schools must take geography until the age of 14. At GCSE, geography continues to rise in popularity (and displayed the greatest percentage change in popularity between 2012-13 amongst the top ten GCSE subjects ( Weeden, 2013). At A Level, geography has maintained a healthy increase in uptake over the 2006-13 period in the UK, returning to the 'top ten A Level subjects league table' in 2013, Weeden 2013.

In contrast, in the USA in 2010, less than half of middle and high school graduates completed a stand-alone geography course ( US Department of Education, 2010).

Whilst geography is not taught as a discrete subject in the USA, there is a relatively long history of US teachers, particularly in the earth and environmental sciences using GIS in their classrooms. As early as the 1980s many of these saw the potential for using GIS to engage their students in enquiry-based learning, particularly for fieldwork and to connect science content to citizenship issues (Milson and Kerski, 2013). Since 2000, the use of GIS in US schools has continued to grow partly because of an increase in funded professional development for teachers and the involvement of the ESRI GIS corporation ( the company that dominates GIS use in industry) developing both a commercial and supportive role in GIS-based school education. In contemporary US school education there remains a growing momentum for using GIS in classrooms. It is important to note that in contemporary classrooms in the USA, it is the science teachers who remain the primary innovators in the use of

GIS. Though GIS is not a required element in most states but there are numerous US teachers across a wide range of subjects including the social sciences and the STEM subjects in particular (science, technology, enterprise and mathematics) developing enquiry-based GIS learning.

Whether discussing the US or the UK settings, GIS in school geography education is characterised by three significant characteristics:

- the nature of spatial thinking with GIS in school geography education
- the role of enquiry learning in GIS-based lessons
- the technical challenges that teachers face in developing both their own ICT-related GIS skills and pedagogies around GIS.

Each of these is examined in the sub-sections that follow.

### 2.10.1 Spatial thinking through GIS in schools

Evidence reflecting the educational benefits of using GIS continues to grow. By far the largest proportion of research on the use of GIS in schools has been carried out in the United States. Emphasis in the research has been placed on the use of GIS in the development of spatial literacy (Kerski, 2003; Bednarz, 2005; Lei et al, 2009). In 'Learning to think spatially' (National Research Council, 2006) the emphasis is on concepts of space, tools of representation and GIScience processes of reasoning makes spatial skills acquisition through GIS very specific. Sinton and Bednarz (2007) made these related claims:

Students in pursuit of a well-rounded education must learn to think spatially (National Academies Press, 2005). Spatial thinking enables us to comprehend and address issues of spatial relationships. As students explore geographical space, they gain the facility and confidence to grasp and imagine abstract spaces, to solve multi-faceted problems, and to think critically and participate actively in our complex, multidimensional world. (Sinton and Bednarz, 2007 in Sinton and Lund, 2007, p19)

In contrast to the educational setting of the USA, the 2008 United Kingdom Geography National Curriculum specifically stipulates that 'pupils should learn to think spatially with GIS.' (DfES, 2008).

The Key Stage 3 programme of study states that pupils should be given the opportunity to learn both about GIS and through GIS in terms of its value and applications in the real world (2008). At GCSE, subject criteria stipulate that learners must be able to demonstrate how to use GIS in carrying out geographical investigations. UK A Level students are expected to use technologies such as GIS to 'synthesise geographical information in various forms and from various sources.' (QCA, 2008). The new UK Geography National Curriculum (due to be taught in schools from September 2014) also indicates that pupils should be taught to use Geographical Information Systems (GIS) to 'view, analyse and interpret places and data' (DfE, 2013).

Whilst acquiring geographical knowledge with GIS is no substitute for real experience of different localities, it can be a very useful pedagogic tool for fixing geographical significance to specific locations. Though evidence on the use of more recently developed GIS (particularly earth viewers such as Google Earth) is not yet substantial, there are clear indications that some geography teachers are beginning to make more use of these in the formal school curriculum, particularly in US schools Baker, Palmer and Kerski, 2009).

The types of GIS used in contemporary school geography both in the United Kingdom and the USA fall into two broad categories: adapted versions of GIS used in industry, e.g. ArcGIS, MapInfo, Idrisi, and geobrowsers such as Google Earth, Nasa Worldwind and Bing Maps. Even though both are digital geographical representations they possess quite different capacities with regards to the contrasts between the analytical functionality of more conventional GIS and the largely earth-viewing capacities of geobrowsers.

It is important to spell out how these distinctive differences in the types of GIS used in most schools (or further afield for that matter) impacts on the user. Even though conventional GIS used in schools tends to be a somewhat 'watered down version', it still requires quite considerable amounts of prior knowledge and skill to operate successfully. Essentially, in order to access even its most basic functionality, users have to be conversant with at least the six main tasks that a 'general purpose GIS' (ESRI, 1996). These include:

- Input
- Manipulation
- Management

- Query
- Analysis
- Visualisation

Before any geographical data can be used in a GIS it needs to be in an appropriate format for use. Whilst in contemporary GIS there are large amounts of data that are already compatible, some still requires converting via a process of digitisation. Using a GIS to manipulate digital data requires the user to perform a number of important routine tasks including transforming data sets to the same scale in data overlay operations and aggregating data to specific areas on a map. Managing large amounts of data requires a huge amount of digital storage space and a high degree of internal management within a GIS. As a result GIS normally uses a relational database to store data in attribute tables with common fields that can be easily cross-referenced (ESRI, 1996).

One of the most significant functions that a user needs to be able to use in a GIS is to query data. At its simplest level this might involve choosing a feature on a map and examining its associated attribute table. At a more complex level, users can query based on a number of attributes to contribute to a deeper level of spatial analysis in the work undertaken (Harvey, 2008). Although querying can be defined as a form of analysis (Harvey, 2008), it is useful in the context of this review to consider analysis as a separate category of task that a GIS user needs to be able to master. Analysis can involve a range of procedures in the most complex of GIS, however in the use of GIS in schools the most common forms of analysis comprise of two distinct forms of analysis. First, a form of distance analysis, second, a form of overlay analysis which may be at a simple level or at a more complex level where layer are related and joined.

#### 2.10.2 Enquiry learning through GIS in schools

A growing body of literature, particularly regarding the use of GIS in US schools, indicates that effective use of GIS can complement enquiry-based geography education (Bednarz 2001). Constructivism in education suggests that where students create and adapt their own knowledge and skills is often associated with the use of GIS in schools. The teacher is seen as facilitator and student peers are often engaged in collaborative learning (Baker, 2000). Specifically within the UK context, enquiry is identified as one of the key aspects of the National Curriculum for Geography (Roberts,

2003) however there is little published research on the contribution that GIS can make to enquiry learning through geography in UK schools.. In conjunction with a GIS, a constructivist approach to learning can allow students to generate a range of digital GI data which they can manipulate and adapt as they decide and require. Linking and layering geospatial information becomes part of the overall learning process but also a pivotal aspect of students' own understanding.

As this discussion has already initially established, several research projects also reveal the significant role that GIS can play in supporting enquiry learning in geography (Scheepers, 2005). The cross-curricular benefits of using GIS have also been investigated particularly in US schools (Sinton and Lund, 2007). In a study of the 2005 Hurricane Katrina disaster, Sinton and Bednarz (2007) examine the ways in which GI spatial data helped the general public better understand the event in terms of both its causes and impacts.

In my MA Geography in Education dissertation, (Fargher, 2004) I investigated the effectiveness of using GIS-based spatial skills to enhance geographical thinking and reasoning about a specific place (Fargher, 2004). Pupils in the research (carried out in a London comprehensive school) used ESRI ArcView GIS software (Malone, Palmer & Voigt 2003) and an adapted version of a GIS activity based on the 1912 Titanic disaster (Kerski, 2003). Participants used a wide range of maps at a variety of scales, photographs, satellite images and statistical databases to assess the main causes of the disaster. They were given opportunities to explore how physical and human processes contributed to the tragedy and to develop a deeper understanding of the geographical characteristics of the specific location where the ship. My tentative findings suggested that pupils benefitted from a learning experience which may have been beyond their access in a comparable learning setting not assisted by GIS, particularly with regards to linking geographical information and visualising more complex geographical phenomena and concepts (Fargher, 2004).

It is important to make clear at this point that the processing of geographical knowledge involves a more sophisticated level of geographical thinking and reasoning. This is reflected in higher quality of learning in school geography where the construction of geographical knowledge has become more configurational. As Ofsted have reported, in these circumstances the best school geography is often more enquiry-based (Ofsted, 2011). The rigorous and highly-structured infrastructure within a GIS lends itself to knowledgebuilding processes which involve constructing knowledge through a set



of stringent spatial querying procedures similar to those illustrated in Rhind's classification(1992) His method contends that this leads a user to ask five generic questions of GI data. Figure 2.4 outlines these key questions.

**Figure 2.4:** Spatial Querying in GIS (after Rhind, 1992)

Question	Type of knowledge construction
What is at?	Inventory
Where is?	Monitoring
What has changed since?	Inventory and Monitoring
What spatial pattern exists?	Spatial Analysis
What if?	Modelling

Figure 2.5 illustrates steps in enquiry most usually followed in the use of GIS in the classroom. The process is designed to mirror the way in which geographical information is processed in a GIS. In a similar way to Rhind's classification (1992), this process involves gathering and storing data in a form appropriate for digital processing but is preceded by asking a 'geographical question'. The question is usually connected with proving or disproving an hypothesis; predicting a spatially-orientated pattern or solving a well-defined problem. Key to this process is that the activities involved in it are centred on producing data that can be mapped, turned into tables and graphs and/or quantified.

In their example of Hurricane Katrina and the ways in which 'geography mattered in shaping the disaster, Sinton and Bednarz (2007), working in the USA discussed the kinds of 'spatial data' that helped people (mainly through the media) understand the event, its causes and its aftermath and build a 'cognitive geographical context.' There is here, I argue an important link about the types of knowledge created and interpreted through GIS. Use in schools is largely dominated by the US ESRI (originally the Environmental Systems Research Institute) which publishes a wide range of educational resources to support and encourage the use of its (commercially available) ArcGIS software (Malone et al; 2005). Figure 2.5 illustrates the application of the spatial querying in GIS concept (after Rhind, 1992) to enquiry learning with GIS in schools as advocated by the ESRI literature:

**Figure 2.5** Steps in enquiry learning with GIS (after ESRI, 2005)

Steps in Enquiry	What to do	Type of knowledge construction
Ask geographical questions	Ask questions about the world around you	Inventory
Acquire geographical resources	Identify data and information that you need to answer your questions	Monitoring
Explore geographical data	Turn the data into maps, tables, graphs and look for patterns and relationships	Inventory and Monitoring
Analyse geographical information	Test a hypothesis, carry out map, statistical, written analysis	Spatial Analysis
Act upon your geographical knowledge	Reach geographical conclusions, inform a decision, solve a problem	Modelling

The term 'enquiry' implies something more than the accumulation of declarative geographical knowledge. In GIS use in schools, where enquiry learning is of a high standard, geography has become more interested in the 'whys of where' rather than pure accumulation of geographical facts (Kerski, 2005).

Research exploring how learning can be enhanced by using GIS has focused on two main learning theories: constructivism and 'optimal flow theory'. Constructivism can be simply interpreted in education as a model of practice where students create and adapt their own knowledge and skills. The teacher is seen as facilitator and student peers are often engaged in collaborative learning (Baker, 1999). A growing body of literature indicates that effective use of GIS can augment enquiry-based geography education (Newcombe 2000; Bednarz 2001). Specifically within the UK context, enquiry is identified as one of the key aspects of the National Curriculum for Geography (Roberts , 2003). In conjunction with a GIS, a constructivist approach to learning allows the student to generate

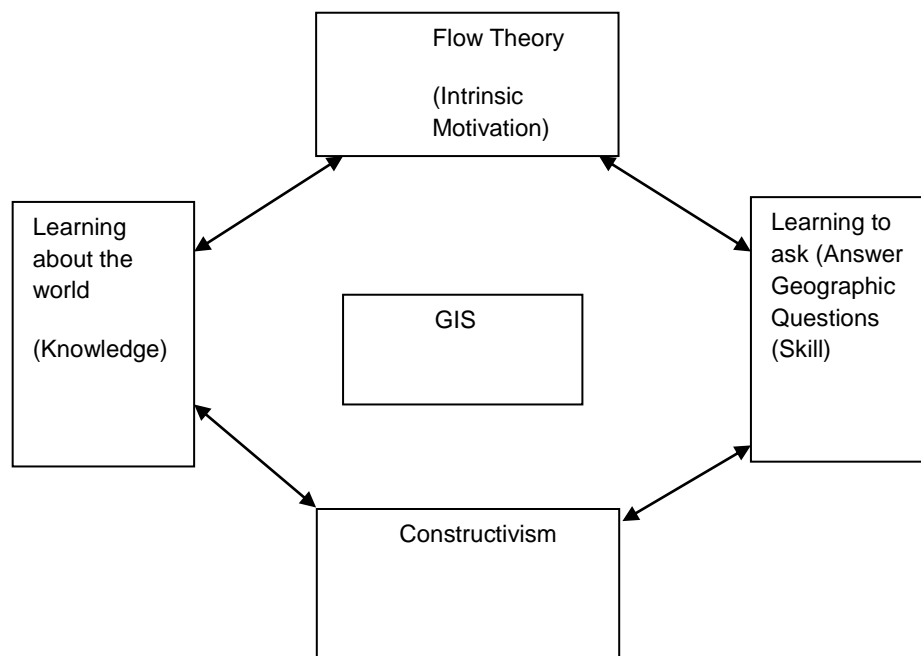
a range of digital GI data which they can manipulate and adapt as they decide and require. Linking and layering geospatial information becomes part of the overall learning process but also a pivotal aspect of student's own understanding.

Another element of the benefits of enquiry learning through GIS has been explored by Smith (2005) with regards to 'optimal flow theory.' 'Optimal flow theory' (Csikszentmihalyi, 1991) describes the cognitive processes associated with an individual's motivation to become involved in a task. In his work: *Flow: The Psychology of Optimal Experience* (1991), the author outlines five major aspects of 'flow':

- (1) An individual being challenged at their own intellectual level. As skills develop, challenge levels also develop
- (2) ) As the person becomes more engaged they become more immersed within the task.
- (3) Mental focus increase noticeably as the individual loses themselves in what they are doing.
- (4) As concentration increases, the individual becomes an integral part of the learning process itself.
- (5) The person is in a state of 'flow' where time passes quickly and outside distractions appear ever-distant.

Figure 2.6 shows how Smith (2005) has further explored the relationship between GIS and learning. This framework *connects* 'flow theory' and constructivism with acquiring geographical knowledge and skills *through* the medium of GIS.

**Figure 2.6** Learning Theory, Geography knowledge and GIS (from Smith, 2005, p 228).

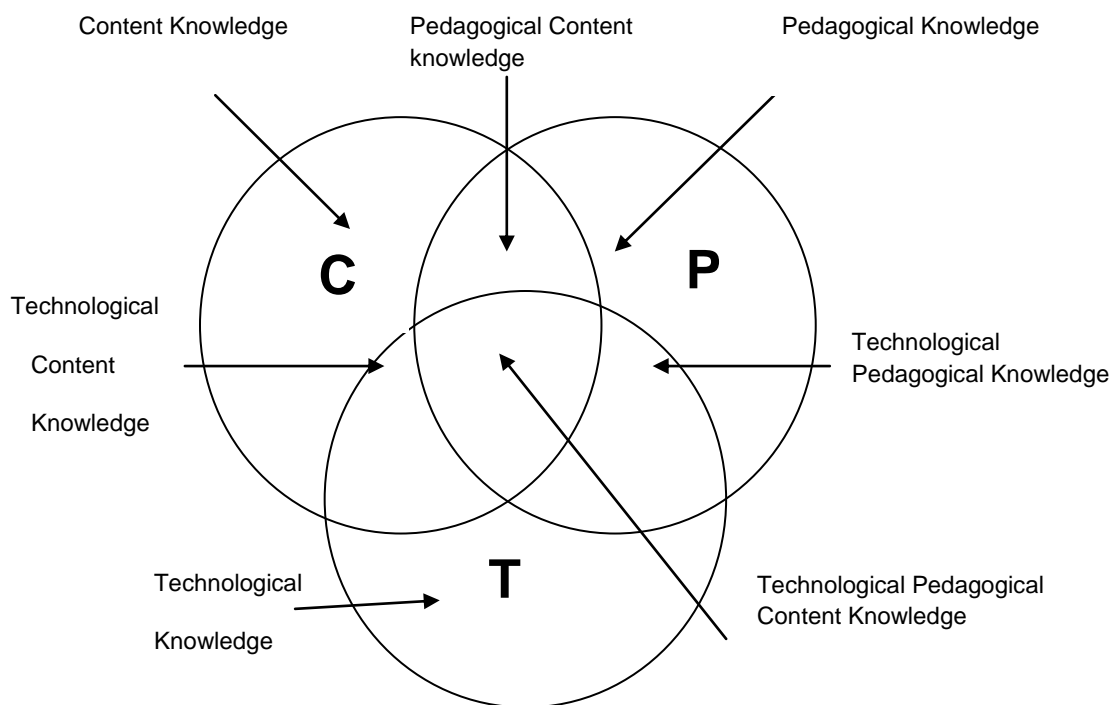


With specific reference to GIS, Smith suggests that effective teaching and learning in often problem-based GIS-related activities tends to encourage a 'state of flow' in involved individuals. Through engaging directly with their own knowledge construction and following the GIS enquiry process, pupils become engrossed in their learning. As pupils become more familiar with GIS, their skill levels improve alongside their broader geographical thinking. Once pupils have grasped the technical elements of using GIS they become more motivated to learn and enter a 'state of flow' similar to that described by Csikszentmihalyi (1991). In conjunction with a GIS, a constructivist approach to learning can allow students to generate a range of geographical information (GI) which they manipulate and adapt as they require. Linking and layering geographical knowledge becomes part of the overall learning process but also a pivotal aspect of students' own thinking and reasoning. A growing body of the literature indicates that this type of use of GIS can augment enquiry-based geography education.

### 2.10.3 GIS Challenges for teachers

Evidence suggests that all ICT-related curriculum innovation requires teachers to develop their pedagogic strategies in considerably more complex ways than they may have done before. They need to be familiar 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. Mishra & Koehler (2006), working in US schools have adapted this concept into a broader pedagogical framework to include a specifically technological dimension. Mishra & Koehler's TPACK 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, 1987). Pedagogical Knowledge (PK) has a broader significance including the elements of the art of teaching and theories about how individuals learn.

**Figure 2.7** The Technological Pedagogical Content Knowledge (TPACK) Model (Mishra and Koehler, 2006).



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 (TPACK) lies at the core of Mishra & Koehler's framework. TPACK requires technological competency, pedagogical skills and firm foundations in subject knowledge. But even more than this they suggest that: 'TPACK is a form of knowledge that expert teachers bring to play anytime they teach.' (Mishra & Koehler, 2006, p15)

Successful GIS-supported pedagogies in geography education are more likely to occur through careful consideration of a framework such as Mishra & Koehler's TPACK. 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 (Fargher, 2006). There are a wide range of other factors at work which contribute to these challenges. 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).

Bednarz and van der Schee (2006), working both in the US and European school contexts, identify external and internal factors which may affect teachers' decisions to become involved in curriculum innovation (Bednarz and van der Schee, 2006). They identify the influence of both external and internal factors in this process. Authority, power, manageability and consistency are as important external influences. For example, seminal texts may sway teachers' attitudes towards and not away from innovation. Power can be directly linked to authority too – compulsory status for fieldwork in the geography curriculum empowers the subject as a whole. Manageability is also seen as a vital factor, with teachers less likely to adopt innovations which are difficult to master. Consistency is cited as an attractive feature too – if an innovation 'fits in' with current practice and systems easily it becomes a more attractive proposition. Important internal factors include previous experience and learning goals. In their 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 and to be able to use a range of ICT skills that could support their students in using databases (Kirschner and 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.

As already specified, the role of GIS in promoting the use of specific spatial skills is well-documented in the USA (Gershmehl, 2008, NRC, 2006). Evidence suggests that only the very best classroom practitioners are using technologies such as GIS successfully (Hay McBer cited in Web and Cox, 2004, p 278). It is true that very little guidance exists for teachers wishing to develop pedagogies involving GIS. It is also clear that already over-stretched teachers, including a large minority of non-geography specialists are unlikely to embrace GIS without a considerable amount of sustained support. Some researcher suggests that difficulties experienced by some teachers confronted by the spatial querying at is an inherent aspect of using GIS is a specific area of teacher training that needs to be more specifically provided for (Bednarz and van der Schee (2006).

## 2.11 Conclusions

This chapter began by discussing the rich theoretical diversity of space and place in modern geographical thought. It moved on to highlight the significance in geography and geography education of one particular reading of place: place as a product of relations. In particular, it identified the philosophical dissymmetry associated with approaching place relationally and representing place through the largely positivistic structures of conventional GIS. The discussion also took account of a number of historical critical responses to spatial science. These included the position of humanistic, neo-Marxist, postmodern and post-structuralist geographies which questioned the validity of representing geographical complexity through the stark confines of traditional GISscience. The development of concepts of place in schools was discussed with regards to these already stated theoretical influences and in connection with the development of the National Curriculum for Geography and its subsequent development and changes to-date.

The second part of the chapter discussed the nature of GIS. In particular, it considers the main principles of GIS, geographical thinking in GIS and critical GIS. The discussion also took into account new developments in GIS, particularly hybrid versions which may hold considerable significance in teaching and learning in contemporary school geography. The penultimate section examined the specific nature of teaching and learning geography in schools with GIS. It focussed on three key elements: the nature of spatial thinking with GIS in education, the central role of enquiry learning in GIS and the challenges for teachers of using GIS in the classroom.

In summary, this chapter has argued that the relationship between GIS and the construction of relational place knowledge in school geography education pivots around three key themes:

- *Relationality*, geographical integration and the nature of synthesis in GIS
- *Spatiality* and the nature of place knowledge in GIS
- *Pedagogy with GIS* in school geography

This list is not complete as yet. The empirical investigations that follow in the thesis will yield more specific additions to the list. These three key themes play a central part as key foci to inform the methodology chapter that follows and the empirical enquiries reported in chapters 4, 5 and 6.



## Chapter 3 Methodology

### 3.1 Introduction

This chapter explains the methodology which underpins the thesis. The chapter is placed here in the writing to act as a bridge between the literature-based conceptual analyses and the schools-based empirical analyses which follow. I begin the chapter by establishing the preliminary specifics regarding my choice of an interpretivist research paradigm. I then examine key questions relating to the ontological and epistemological assumptions which have steered the methodology. In particular, I spell out the significance of my own relativist ontological stance and how this view led to me founding the research firmly on a constructionist epistemology. I then examine the research design which has been organised into three sections and provides an overview of the contexts of the three empirical case studies. It is important to re-iterate again at the start of this chapter on methodology that although these are three separate studies, their collective value in supporting the claims made in the thesis as a whole is significant and the chapter spells out the rationale for and description of the three sets of data collection and analyses and critically examines these approaches. It is also worth noting at this point that Chapter 8 includes a review of the advantages and drawbacks of having had a three-part empirical structure to the research as a whole. The penultimate section outlines approaches to ethical issues that have arisen during the course of the research. A summary of the key elements of the research methodology is presented at the end of this chapter.

Dunne, Pryor and Yates provide a useful description of research as process which I have found useful in shaping my methodology. They claim:

The research process, virtually universally, begins with a concept and ends with a text. The space in between is normally given shape and coherence by decisions we make about how to proceed; collectively those decisions comprise our methodology and this determines what we do as researchers and how we understand our actions and experiences and those traces of the social that we construct as data.(Dunne, Pryor and Yates, 2005, p11)

As was argued in the previous chapter, other research findings indicate that GIS is a powerful medium for relational spatial analysis in geography (West, 2005; Fargher, 2006). However, despite its power to manipulate, transform and analyse digital spatial data, its potential for integrating and representing relational knowledge about place has been under-explored. I also examined the variety of theoretical approaches to place and space in geography and GIS. By acknowledging the importance of the rich plurality of approaches to place and space in geography, whilst highlighting concerns about the reduction of these in the quantitative/spatial paradigm, my intention was to open up opportunities for debate about how GIS influences how individuals view place.

In seeking to explore the relationship between using GIS and constructing relational knowledge about place, I began to consider two key theoretical perspectives: the objective, positivist ways in which place is regarded in GIS; and the subjective nature of the ways in which an individual (whether using GIS or not) comes to *'know their world'*. There is a sense in which the fundamental aim of this research is to examine how GIS can be operationalized to synthesise and represent relational knowledge about place through geography education. Specifically it seeks to examine the influence of concepts, tools and processes of GIS in constructing relational knowledge about place in geography education.

Therefore, the main purpose of this chapter is to make explicit the reasons behind decisions made in adopting my research strategies and design. Schostak and Schostak (2008) raise important questions about what research 'design' hopes to achieve. They ask: 'Does it seek to settle a question, resolve an issue, promote a course of action, and map the terrain of an unknown territory?' (Schostak and Schostak, 2008, p 9). Michael Apple contends that a simple set of questions usually underpin critical research in education (Apple, 2004). The a priori and continuing question that arises in this research is: *What role does GIS play in school geography in constructing relational about place?* In order to fully engage with the nature of the way in which place is 'made in GIS' and the processes at work in conceptualizing teaching and learning about place with GIS, this research addresses three further key questions:

- *How does GIS influence teacher practice?*
- *How does GIS influence how teachers construct knowledge about place?*
- *How does GIS influence how pupils interpret place?*

My choice of these three further questions is important to consider and justify more fully how I came to phrase the latter. First, I chose to focus specifically on GIS, the geographic information system itself and how its principles, procedures and outcomes specifically affected how teachers operated in teaching geography through GIS. In particular, I wanted to isolate and examine closely their specific GIS practice in direct relation to the collection of and construction of information about place and the ways in which they and their students constructed place knowledge together through GIS. In relation to the latter, I also purposely wanted to consider the ways in which pupils wrote about and discussed their interpretations of place through GIS, hence the formulation and phrasing of the third research question. In choosing to use 'influence' of GIS on teacher practice, place knowledge construction and pupil interpretation of place my intention was to isolate the role of GIS as much as possible in the research. I was very aware that I could not consider all factors affecting how the research teachers taught in their lessons or how their pupils learnt about geography per se or place in particular but I could narrow my focus specifically to the guiding role of GIS in knowledge construction by looking specifically at key elements of their practice. I was open to collecting a range of data connected with the influences of GIS in an 'interpretivist research sense' – I looked intentionally to develop associated naturalistic research methods, mainly observation, interviewing and analysis of existing literature on the influence of GIS in teaching and learning school geography. To these ends, embedded within the research questions is a commitment to conveying *in-depth description* of research participants' experiences. In order to meet this central pre-requisite, the research strategies include the four key elements of the *qualitative research paradigm* (adapted from Bryman, 2008). These are first, developing understanding of *behaviour in context*; second, including the *recording of actions from the perspectives of those being studied*; third, providing *rich description* and fourth, adopting a *flexible, open-ended structure* which can allow for changes in emphasis during the course of the research and changes in direction. In the next section, I consider further how the choices of research questions were directly related to the ontological and epistemological assumptions underpinning the research, how key conceptual frameworks link with these and further informed the research process. Though not completely fool proof (as the discussion on elements of the research which did not quite work out to plan develops in Chapter 8), I also consider how this forethought contributed to the robustness of the research project in terms of 'fitness for purpose', validity and reliability.

### 3.2 Key methodological questions

The first main part of this discussion on methodology scrutinizes closely the links in the research between its key and underpinning theoretical perspectives and the choices made about method. It does this by addressing four key methodological questions:

- What are the ontological and epistemological assumptions underpinning the research?
- Which conceptual frameworks have informed the research process?
- How does this research address the key concepts of 'fitness for purpose' validity, reliability?
- How do the conceptual frameworks relate to the collection and analyses of data?

#### 3.2.1 Ontological and epistemological assumptions

Establishing the nature of the theoretical perspectives which underpin methodology is an essential element of all credible research (Crotty, 1998; Denscombe, 2002; Robson, 2005). Crotty defines theoretical perspective as:

A way of looking at the world and making sense of it. It involves knowledge, therefore, and embodies a certain understanding of what is entailed in knowing, that is, how we know what we know. (Crotty, 1998, p8)

Theoretical perspectives influence strongly 'what sort of thing society is ('the ontological assumptions') and how one goes about gaining knowledge of it ('the epistemological assumptions'). It follows that research can never being considered as a neutral tool because theorizing is part of the research process that involves not just ways of looking at the world but also ways of approaching the research process as a whole (Woodiwiss, 2005). Fundamentally, how we approach research determines its outcomes. In *Scoping the Social: an introduction to the practice of social theory* (2005), Woodiwiss provides a convincing discussion about the importance of this perspectival framing. He argues:

'Theory' consists of words formed into a set of interlinked concepts – change the words and you change the concepts and therefore the theory (Woodiwiss, 2005, p9)

A discussion about how we come to know place leads to deeper epistemological questions about our individual thinking as researchers, and the particular ontological premises that this brings with it. Logically, it matters that individual theoretical perspectives underpin the ways in which researchers represent and analyse their data. Dunne, Pryor and Yates (2005) discuss the importance of how we think we can have knowledge as researchers. They argue:

What sort of entity we think the social world is and how we think we can have knowledge of it is an a priori and continuing question in relation to the research process. The question is prior because how we answer it conditions the way we set up and conduct our research; and it is continuing because it can be modified by our reading and understanding and by the experience of research. (Dunne, Pryor and Yates, 2005 p 14)

Ontologically, it is important to consider is the object of the research, in this case, place, an independent entity which exists completely separately to the individual or is it a social construction? To consider place as an independent physical reality is a realist viewpoint that I do not personally share. I tend towards a more nominalist viewpoint which is to say that though I acknowledge the place can be interpreted as a physical entity – as a location for example – I view the concept in its totality as one which is a product of cognitive construction – 'a way of seeing, knowing and understanding the world.' (Cresswell,2004, p11).

As the conceptual analysis in the last chapter indicated, the theoretical landscape underpinning this research is complex. That discussion highlighted key areas of the academic literature which indicate that space and place can be interpreted from a broad and varied range of philosophical perspectives. Figure 2.1 identified the diverse nature of spatiality and highlighted the key philosophical dissymmetry between viewing the world objectively (as GIS is largely designed to do) versus broader, more relational interpretations of space and place. In the remainder of this discussion on ontology and epistemology I consider the nature of both objectivism and subjectivism and their relevance to the research in more detail and begin to elaborate on how both theoretical perspectives have had important roles to play in informing the methodology.

Epistemologically, objectivism holds that reality exists independently from human influence where elements of that reality (its ontological components) are seen as facts to be discovered, detached from human emotion or bias. Such an objective theoretical perspective suggests that causal relationships between objects or variables can be identified, hypotheses can be tested and scientific laws can be adhered to via positivist principles (Lather, 1991; Robson, 2005). Based on this type of objective thinking, the philosopher, Auguste Comte developed the theory of *logical positivism* to suggest that knowledge is acquired through direct experience of the observation of facts. Historically, objective knowledge has become for some almost synonymous with scientific knowledge. As a result, *knowing the positivist world* is value-free. Robson provides a useful summary of this way of thinking. He argues:

Essentially, positivists look for a constant relationship between events, or in the language of experimentation, between two variables. This can be relatively straightforward when dealing with the natural world, although calling for considerable ingenuity and the ability to control the conditions of the experiment – which is why laboratories exist. However, when people are the focus of the study, particularly when it is taking place in a social real world context, ‘constant conjunction’ in a strict sense is so rare as to be virtually non-existent (Robson, 2005, p 21)

Robson highlights the philosophical gulf between the clinical nature of scientific knowledge and the less-easily categorised, messy nature of human knowledge. Whilst objectivism suggests that we come to know the world through discovery of an already fixed, *objective* reality, subjectivism suggests that knowing the world is a unique, *personal* experience. Specifically, it is through our individual conscious and sub-conscious thinking, that we filter and shape our own version of ‘knowledge.’ In his discussion about the significance of consciousness and the nature of subjective thinking about the world, Searle (1999) argues:

Conscious states are subjective in the sense that they are always experienced by a human or animal subject. Conscious states, therefore, have what we might call ‘first-person ontology.’ That is, they exist only from the point of view of some agent or organism or animal or self that has them. (Searle, 1999, p 42)

Throughout the thesis I argue that geographical information construction through GIS is strongly influenced by objectivism and a particular view of spatiality which strongly influences the nature of geographical knowledge that can be ‘made’ in a GIS. The empirical studies in this research are

founded on finding out how teaching and learning within these frameworks influence the construction and interpretation of relational place knowledge in the geography classroom.

In summary, in line with Geertz's interpretive approaches to adopting research methods suitable for developing complex social settings such as classrooms (Geertz, 1972) this interpretivist research is founded upon a constructionist epistemology which acknowledges that how we come to know the world is determined by human practices through which knowledge is shaped and determined by its social context (Crotty, 1998).

### 3.2.2 The conceptual framework

Conceptual frameworks tie the theoretical underpinnings in research to its empirical strategies. By 'conceptual framework', I am referring to the set of guiding themes that inform theorizing in research. The main question in this research is: *How does GIS influence the construction of relational knowledge about place in school geography education?* The question hinges on three guiding concepts which I define as: *place constructs*, *pedagogy* and *dialectical theory-building*. I identify two different kinds of *place construct*:

- *Physical place constructs* including maps, satellite imagery and other combinations of digital GI and written information produced by pupils, teachers or both
- *Verbal place constructs* which include interpretations of place which have emerged in the data collected from pupils and teachers

My second key concept, *pedagogy* is used to refer to nature of the teaching and learning processes investigated in the research. The third concept, *dialectical theory-building* refers to the process of inductive –iteration which underpins the entire research process. Dialectical theory-building came to work on a number of levels in the research. I set out from the start to build knowledge derived from both the conceptual and empirical analyses in tandem. A number of key themes were identified in the literature-based conceptual analysis and these were used to feed into the planning for the empirical work that followed.

### 3.2.3 Fitness for purpose, validity and reliability

Though recent educational research in the United Kingdom has been criticized by some for its lack of rigour and credibility (Hargreaves, 1996; Tooley and Darby, 1998; Gardner & Galanouli, 2004) both qualitative and quantitative research methodologies which display 'fitness for purpose' (Cohen & Manion, 1994) can be very effective. 'Fitness for purpose' is considered to be *de rigueur* in credible research regardless of its qualitative, quantitative or mixed-method nature (Cohen and Manion, 1994).

Research texts abound with a range of advice about finally producing a (research) design that is 'fit for purpose'. Crotty, (1998) encapsulates the conundrum facing researchers in the early stages of the research process. He argues:

As researchers we have to devise for ourselves a research process that serves our purposes best, one that helps us more than any other to answer our research question. Having perused and mused over the opinions and procedures of this array of scholars and practitioners, we are in a much better position to do that. We engage in a running conversation with these thinkers. We knock our ideas against theirs. We glean from them an understanding of what is possible in research. Importantly we become better able to set forth the research process in ways that render it transparent and accountable. (Crotty, 1998, p 216)

I identify with Crotty's description because he implies exactly what can be gained for the research from 'knocking the ideas' of others against once own when choosing methods. In the early part of planning the research I made such decisions about employing first, quantitative, qualitative or mixed-method approaches. The influence of other research on GIS in schools has often been quantitative and this approach was my first avenue of thought as this discussion will show.

In: *Education and Theory*, Thomas (2007) equates building 'correct' research methods with the ways in which paradigms in science (mainly derived from the writings of Kuhn, 1970) have been constructed as the 'right ways' of concretizing a *rational* approach to creating knowledge. Thomas argues that much educational research is approached in a similar almost unquestioning way. His claim – that research students experience a very literal approach to the business of methodology



reflect my own early experiences as a new researcher. I was introduced to the rudiment concepts of 'theory, ontology, epistemology, reliability, validity' in a quite passive learning experience something Thomas describes this as introducing a kind of 'stereotypy' into the researcher's practice (Thomas, 2007, p 92). Initially, during the early stages of the research, I explored method in this way with regards to two approaches, one quantitative – through measurement of cognitive load theory (CLT) and one largely a qualitative approach to grounded theory method (GTM).

### *i Experimenting with cognitive load theory*

Cognitive load is the impact of a task on an individual's mental processing capacity. Cognitive load is measurable (Kirschner, 2002). Cognitive load theory (CLT) can be used to support research that involves the representation of geographical knowledge. Of particular significance is the use of CLT to contribute to empirical research which uses maps as primary sources of information (Bunch and Lloyd, 2006):

By considering the limitations of the human mind, CLT offers geographers a way to assess critical components of the spatial learning processes.

(Bunch and Lloyd, 2006, p 209)

Cognitive Load Theory (CLT) identifies three different components of cognitive load: *Intrinsic load*, *extraneous load* and *germane load*. Intrinsic cognitive load refers to solely to the interaction between learner and task. Extraneous cognitive load can involve external influences. For example, poorly designed instruction places an extraneous cognitive load upon an individual learner. Recent research suggests that germane cognitive load can enhance learning with digital geographical information by facilitating the construction and automation of cognitive schema (Bunch & Lloyd, 2006). Cognitive load is a complex procedure. In an early cognitive load study, Paas and Merrienboer measured mental load, effort and performance using objective methods (Paas and Merrienboer, 1994). In one study, Paas, Renkl and Sweller (2003) used both subjective and objective methods to calculate cognitive load. Analytical methods have also been used to measure mental load using techniques such as expert opinion and collection of data using mathematical tools (Paas, Tuovinen et al; 2003). Studies measuring mental effort have included: rating scales; performance testing and psycho-physiological techniques. Others have included mixed-methods

which included questionnaires. My initial examination of the cognitive load theory literature also led me to explore how significant independent variables may affect how students construct knowledge about places with GIS. My intention was to use quantitative methods, particularly regression analysis. I began by formulating hypotheses which would test the statistical significance of variables including gender, age, expertise and instruction. By formulating such hypotheses I was attempting to explicitly test the strength of the relationships between these independent variables and the dependent variable: GIS-assisted knowledge construction about place. By examining a number of classes, I intended to use Z-scores to standardize my data and allow me to compare the distributions.

Whilst I agree with Bunch and Lloyd (2006) that *managing* cognitive load experienced by users of technology such as GIS is important to consider, I came to the conclusion that investigating cognitive load further in the thesis is not appropriate for a number of reasons. Whilst cognitive load and GIS competence can be quantified, individual interpretation of place cannot – emotional engagement with place requires richer, 'thicker description' (Geertz, 1973). This, I concluded is more likely to be revealed through observation and interview, adding elaboration to case study (Rubin and Rubin, 2005) and as the empirical chapters that follow show, supplementing and expanding on these findings with practitioner research.

#### *ii Experimenting with grounded theory method (GTM)*

Another important element of my early experimentation with other methodologies involved grounded theory method (GTM). Grounded theory implies that theory can be found inductively through direct engagement with the empirical world. As Bryant and Charmaz (2004) argue about the knowledge claims underpinning grounded theory:

A key strength, and one still central to GTM, is that it offers a foundation for rendering the processes of qualitative investigation visible, comprehensible and replicable. (Bryant and Charmaz, 2007, p33)

In the early stages of my research, this type of legitimization appealed to me. In her analysis of Strauss and Glaser's '*Discovery*', Hood (2007) provides a useful outline of summary of the key

elements of their early version of Grounded Theory. I reproduce and comment on it here because it helps to contextualize why I experimented with GTM. Hood describes Grounded Theory as:

1. A spiral of cycles of data collection, coding, analysis, writing, design, theoretical categorization, and data collection.
2. The constant comparative analysis of cases with each other and to *theoretical categories* throughout each cycle.
3. A *theoretical sampling process based upon categories developed from ongoing data analysis*.
4. The size of sample is determined by '*theoretical saturation*' of categories rather than by the need for demographic 'representiveness' or simply lack of 'additional information' from new cases.
5. The resulting *theory* is developed inductively from data rather than tested by the data, although the developing theory is continuously refined and checked by the data.
6. Codes '*emerge*' from data and are not imposed *a priori* upon it.
7. The substantive and/or formal theory outlined in the formal report takes into account all the variations in the data and conditions associated with these variations. The report is an *analytical product rather than a purely descriptive account*. *Theory development is the goal*.

(Hood, 2007 cited in Bryant and Charmaz, 2010, p1)

My central aim in attempting to find out if GIS influences how knowledge is constructed about place initially steered me towards iterative -inductive processes - collecting data, analyzing it and attempting to derive theory from it. This moving between data, analysis and theory borrows ideas from early grounded theory approaches, particularly repeated comparison of data collected and theoretical sampling (Glaser and Strauss 1967; Cohen, Manion and Morrison, 2000). In the pilot study that I conducted with GTM, I began following their methods by splitting up my observation and interview 'findings' into categories, 'grouping' responses and 'allocating' them with 'codes.' This process in itself was informative but through repetition of reductionist coding I began to lose the rich description of teaching and learning processes that I wanted to glean. Whilst I may not agree completely with Thomas's outright dismissal of grounded theory, I do recognize elements of his opinion about it in my own rejection of it. He suggests that:

Grounded theory (if indeed grounded theory is theory, and that's something I'll examine) destroys that which it seeks to unlock and explain.

(Thomas, 2007, p117)

I am aware that advocates of grounded theory method may question my reasons for deciding not to pursue it. For example, Corbin and Holt are forceful in their disdain for methodologies that list themes, describe phenomena but do *not* consider theory to be the ultimate result of research. They argue that:

Developing a grounded theory is not for everyone. From the outset one has to be very clear that developing theory, not a listing of themes or a description of a phenomenon, is the goal of the research.

(Corbin and Holt, 2005, p51)

I think that James Scheurich's thoughts (Scheurich, 1997) are also significant in this discussion. I acknowledge that he is talking more generally about broader reductionist influences of modernity, but his sentiments about grounded theory ring true from my research perspective. He suggests that:

The modernist representation is not sheer fabrication but all of the juice of the lived experience has been squeezed out, all the 'intractable uncertainties' and the unstable ambiguities have been erased. (Scheurich, 1997, p 63)

### *iii. Choosing 'thick description'*

As I experimented further with a range of methodologies it became clear that being able to fully engage with my first two key concepts of *place constructs* and *pedagogy* would mean that the need to glean rich information from my data was my overriding priority. In his essay *Thick Description: Toward an Interpretive Theory of Culture*, Clifford Geertz (1973) examines the implications for understanding complex social settings (such as school classrooms) that I found instructive. Geertz places emphasis on developing explanatory conclusions rather than developing and assigning reduced category of meaning which can detract from holistic understanding of complex social contexts. He argues:

Cultural analysis is (or should be) guessing at meanings, assessing the guesses, and drawing explanatory conclusions from the better guesses, not discovering the Continent of Meaning and mapping out its bodiless landscape.(Geertz,1973, p18)

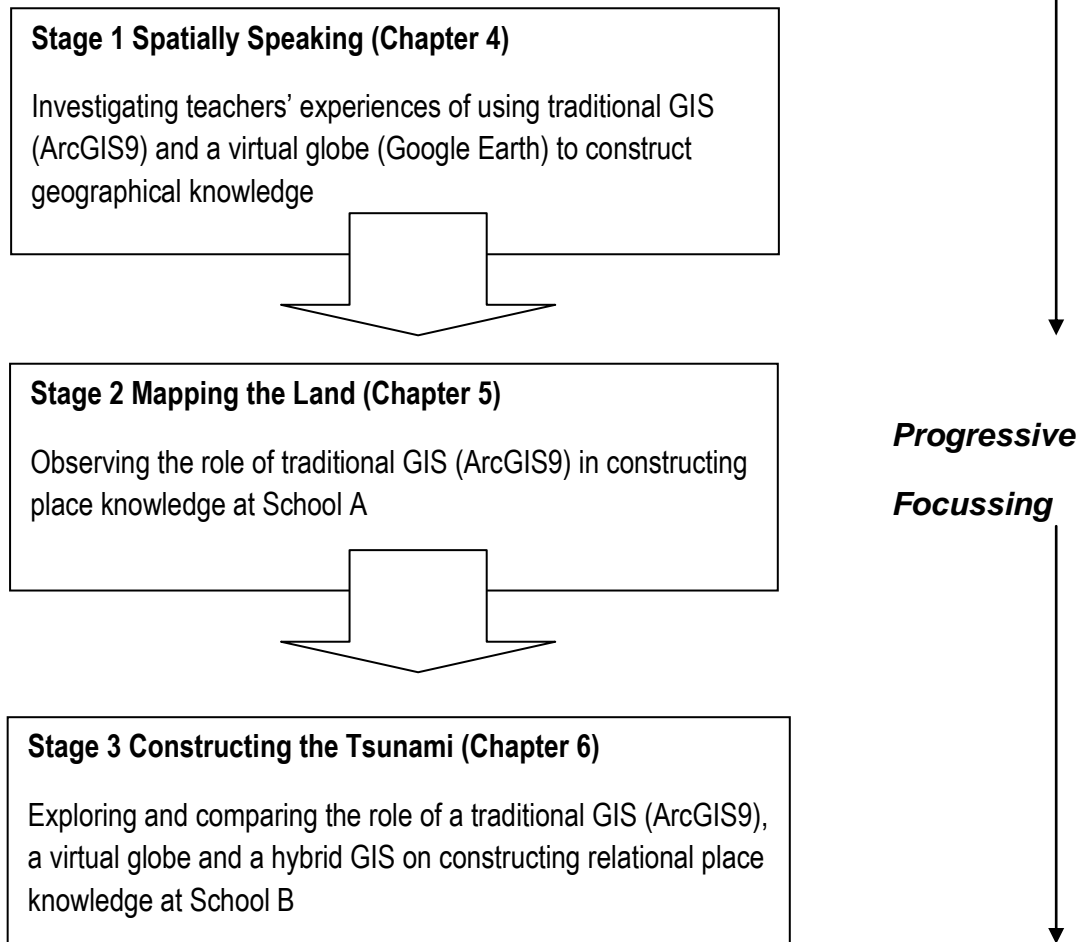
In moving away from grounded theory method, I did not reject iterative approaches completely. Neither did I completely reject the notion that this research might still contribute to theory-making about the use of GIS in classrooms. But, significantly, by switching methodological approaches to a 'thick description method' allowed me to record fuller details of teaching and learning about place through GIS.

In further connection with dialectical theory-building, Patti Lathers' ideas of making this kind of research more empowering I built in opportunities for reciprocity where I could link the conceptual analyses with the empirical analyses at key points in the data collection. Lather, (1991) states:

The implications of looking to make research 'empowering' involve the 'need for reciprocity, the stance of dialectical theory-building versus theoretical imposition, and the question of validity in praxis-oriented research. (Lather, 1991, p 56)

The research has moved firmly towards the development of theory about the construction of place knowledge with GIS but via iteration and developing significant themes as part of the ongoing process. With this in mind, the methodology has also been driven by what Stake (1991) describes as "progressive focussing" (1991), moving from the broader focus on the role of GIS in affecting teachers' practice per se (Chapter 4) to the more specific emphasis on teaching and learning about place through GIS (Chapters 5 and 6). Figure 3.1 spells out the exact nature of the progressive focussing in the research. As the diagram illustrates, in accordance with my choice of an interpretivist research paradigm, the research methods are qualitative and meanings in the research emerged and developed as the research progressed.

**Figure 3.1** Progressive focussing (after Stake, 1981)



### 3.2.4 Description and analysis

In terms of internal validity (looking at how data collected from the research project and the schools in the research might be interpreted), my focus was on the key actors namely pupils and their teachers mediating GIS in learning and teaching about place but there was an inevitability about my having to restrict my data collection in some ways. In her discussion about research design, Grbich (2004) discusses these types of challenges of selecting population samples. She contends:

As parameters vary and dimensions of a given population change, it is somewhat pointless to emphasise homogeneity, particularly when there is recognition that this is artificial, that

variables cannot be controlled precisely, that individuals are changing entities and that a quick snapshot bounded by time and context is all that can be achieved. (Grbich, 2004, p 61)

As Grbich implies, one of the challenges in research is to ensure that data collection and analyses reflects the issues emerging from the data collected as well as reflecting the key elements of the research's conceptual framework. In this research, as I investigated a range of methodologies, it became clear that being able to fully engage with my key concepts of place constructs and pedagogy would mean that the need to consider both the findings from my conceptual analysis and to glean rich description from my empirical data. With the latter in mind, I built in dialectical theory-building into the two main methods of collecting and analyzing rich data: Case study and practitioner research.

### 3.2.5 Case study

Case study is not easily defined as one coherent form of research. Rather it can be classified as an 'approach' which emphasises in-depth study in situ but also one about which there are conflicting opinions about the degree to which the case study researcher can produce a definitive account of the 'case' from 'the outside' (Stark and Torrance, 2005). What is commonly agreed about case study research is that it seeks to engage with and report upon the complexity of social activity and interaction within a strongly defined setting or 'bounded system' (Stake, 2008, p 119). The major strength of case study is that it takes an example of 'an instance in action' (Walker, 1974) and uses multiple methods and sources to interrogate and interpret it. Put simply, case study provides context-dependent knowledge which can help to inform professional understanding of a small, bounded setting e.g. a classroom. As Flyvberg (2011) argues:

Context-dependent knowledge and experience are at the very heart of expert activity. Such knowledge and expertise also lie at the centre of the case study as a research and teaching method; or to put it more generally yet—as a method of learning. (Flyvberg 2011, p 303)

Case studies are particularly valuable in theory-building because they provide opportunities for developing and testing already established historical explanations. In effect, using a case study to test a theory or a hypothesis helps to develop understanding of key processes in context (George and Bennett, 2005).

A key element in the success of using case study lies in choice of focus. This may seem rather obvious but case studies are almost universally chosen because the researcher sees the case in point as being a particular opportunity to learn. Stake argues:

The researcher examines various interests in the phenomenon, selecting a case of some typicality, but leaning towards those cases that seem to offer opportunity to learn. My choice would be to take that case from which we feel we can learn the most. That may mean taking the one that we can spend the most time with. (Stake, 1994, p101)

Decisions need to be made about the time that can be spent onsite and which methods can be most effectively employed. A key implication for case study research design is the choice between depth and coverage. At the point where I was planning the case study elements of the research, I chose to focus on Spatially Speaking as the first case and School A as the second because of the potential that they held for gleaning thick description of data (Geertz, 1973). Working with the Spatially Speaking group gave me access to data that I otherwise would not have been able to analyse quite so readily. In a similar way, the geography department at School A was run by an 'expert member' of the Spatially Speaking project. I chose School A as a case, which intuitively stood out for me as possibly being both critical and paradigmatic, an example of 'expert use' of GIS in classrooms that I could use to reflect on and inform my practitioner research. In short, my intention was to glean evidence from the cases which could be used to model processes of teaching and learning about place through GIS

Caution about case study is often raised with regards to not being able to generalise from findings based on a single case. However, testing of hypotheses relates directly to the challenge often made to case study approaches that 'generalizability' is difficult to achieve in this kind of research Bassey (1999). It can be argued that on the contrary, atypical or extreme cases can reveal more information because of the in-depth detail and rich description involved in such a case. In his discussion on the validity of using case study approaches in research, Giddens (1984) argues:

Research which is geared primarily to hermeneutic problems may be of generalized importance in so far as it serves to elucidate the nature of agents' knowledgeability, and thereby their reasons for action, across a range of action-contexts. (Giddens 1984, p 328)



Questions raised about generalizability and case study are closely connected with the key role that choice plays in case study research. Strategic choice of case can increase generalizability. It is often more important to generate deep description within one case than to generalise across several. Random sampling is unlikely to yield such detail or insight. It can also contribute to the preliminary stages of an investigation in order to either generate or reaffirm hypotheses. In this way, concrete case study knowledge becomes a valuable part of theory-building.

Ultimately, my choice of case studies reflected my intention to generate 'data' which illustrates the influence of GIS on knowledge construction in school geography education. I chose specific cases which I perceived to have the potential to yield rich data (Yin, 1994). With regards to reliability, I make the case for the research results being repeatable in other contexts. In consensus with Schofield (1990) I argue that the adoption of 'thick description' as method in research strengthens a case study because data becomes more generalizable when: 'the fit between the situation studied and others to which one might be interested in applying the concepts and conclusions of that studied'. (Schofield, 1990, p 226). The central argument that I put across in this instance is that each of the case studies in this research, the Spatially Speaking project and the Mapping the Land case exhibit sufficient similarity to GIS practice in school geography elsewhere in the United Kingdom to be considered 'generalizable.'

I have triangulated data and analyses in the research which is recognized good practice in research which seeks to be reliable (Miles and Huberman, 1998). By comparing data collected in the Spatially Speaking and Mapping the Land stages with my action research findings in Chapter 6 I aimed to enhance the reliability of my final research findings (Sapsford and Jupp, 1998).

### 3.2.6 Practitioner research

In its simplest form, practitioner research (also termed as action research) involves a cycle of planning change, carrying out 'actions', monitoring their implementation and evaluating their impacts (Lewin, 1988). In reality, practitioner research rarely reflects these clearly-cut stages. For example, whilst the researchers' primary aim may be to improve understanding of a key process in their

professional practice, this may involve multiple starting points which lead to an overall research structure characterised by a rather less than the orderly sequence of events (Noffke and Somekh, 2005). This involves the researcher reflecting iteratively on theory whilst acting, a process which Schon (1983) equates with 'knowing-in-action.' My decision to carry out practitioner research was related to further developing understanding of the processes involved in teaching and learning about place through GIS from an insider's perspective in the classroom.

There are several reasons why practitioner research is identified as a credible approach to studying education. Practitioner research aims to improve understanding of professional practice (Carr and Kemmis, 1986). In particular, it seeks to develop practice informed both by theory in the field and the direct experience of the research (Somekh, 2005). As key actors, teachers, play a central role in curriculum research and development in education (Teahouse, 1975). It follows that there is a well-established history of practitioner research approaches being used in school education. Stenhouse's Humanities Project (1975) raised the profile of the classroom teacher's central role in curriculum development research (Somekh, 2000). Recent practitioner research studies in education have placed more emphasis on investigating the nature of teaching and learning processes to enhance professional practice (Borda, 2001).

Having described and justified the main approaches to data collection, the next section turns more specifically to matters of research design.

### 3.3 Research design

Figure 3.2 shows the research divided into the three key stages and shows their relationship to the research questions. Stage 1 is the first case study empirical stage (*Spatially Speaking*) which focuses on the experiences of nine teachers involved in a CPD project on GIS. During this stage of the research I present a secondary analysis of data that I collected during the Geographical Association's 2005-7 *Spatially Speaking* project (Fargher, 2006). This stage of the research focuses on describing teachers' construction of geographical knowledge through ArcGIS and Google Earth.

Stage 2 is the second case study empirical stage (*Mapping the Land*) which focuses more specifically on experiences of one of the *Spatially Speaking* teachers and a group of his pupils using GIS to study

place. This stage of the research focuses on describing the construction and interpretation of place knowledge through ArcGIS.

Stage 3 is the practitioner research empirical stage (*Constructing the Tsunami*) which focuses on my experiences as a teacher researcher using GIS to teach about place through ArcGIS, Google Earth and hybrid GIS. This stage of the research develops the focus on describing the processes of constructing and interpreting place knowledge through ArcGIS, Google Earth and hybrid GIS.

It would be disingenuous to portray the process outlined above as having been straightforward and linear. Instead, it has involved an on-going and evolving cycle of creating and adapting methods in an iterative process.

**Figure 3.2** Research design

Research Questions	Stage of Research	Aim	Procedure
1) How does GIS influence teacher's practice?	1) Spatially Speaking	This stage of the research examines the influence of GIS on teacher practice in terms of geographical aims, processes of knowledge construction, teacher and pupil outcomes	Analysis of teacher interviews and written reports
2) How does GIS influence how teachers construct knowledge about place?	2) Mapping the Land	This stage of the research examines the processes of constructing and interpreting place knowledge through ArcGIS	Lesson observations, teacher interviews, document analysis
3) How does GIS influence how pupils interpret place?	3) Constructing the tsunami	This stage of the research examines the processes of constructing and interpreting place knowledge through ArcGIS, Google Earth and a hybrid GIS	Lesson observations, pupil interviews, document analysis

### 3.4 Data collection and analysis

Good research analysis results from clear understanding of research data (Spiggle, 1994). This kind of systematic approach implies both rigour and organisation where the researcher seeks to identify patterns, recognize themes, develop interpretation, critique findings, support existing theory and/or generate new ones (Hatch, 2002). Wolcott (1995) provides an illuminating description of researcher 'mind work' as a way of interrogating qualitative data so that meanings identified can be clearly represented to the researcher's audience. In a similar way, Leech and Onwuegbuzie (2007) contend:

Representation refers to the ability to extract adequate meaning from (the) underlying data. Using multiple qualitative data analyses combines the strengths of each qualitative analysis tool involved in order to understand better the phenomenon. (Leech and Onwuegbuzie, 2007, p 579)

Figure 3.2 shows how this research use multiple stages of data analyses to better understand how place knowledge is constructed and interpreted through GIS in school geography. Dunne, Pryor and Yates (2005) discuss the value of this conscious process of deliberation in creating research design. They state: 'anticipation of analysis is an important consideration in the development of research designs and indicates logic for the inquiry.'(Dunne, Pryor and Yates, 2005, p 83). With this in mind, I adapted my approach to include:

- reference to the *guiding themes* in my conceptual framework, namely *pedagogy* (teaching and learning) and the related, but categorised separately, concept of *place constructs*;
- methods which would allow for consideration of *independent themes* emerging from the data

Stage of Analysis	Dataset	Aim	Procedure
Stage One (Chapter 4)	Stage 1 Spatially Speaking	Analysis of data set 1	
Data collection	Dataset 1 Database of teacher interview responses and written reports (from Fargher, 2006)		
Data coding Part 1		To identify emerging themes	Open coding
Data coding Part 2		To amalgamate similar coded categories	Comparison coding
Data display		To map themes emerging in the data against conceptual framework themes	Mapping of emerging data themes connected with geographical aims, processes of knowledge construction & teaching & learning outcomes against conceptual framework themes of pedagogy & place constructs
Data analysis		To describe teachers GIS practice	Thick description of data
Interim findings		To summarise interim findings	Summary of findings

Stage Two (Chapter 5)	Stage 2 Mapping the Land	Analysis of data set 2	
Data collection	Dataset2 Classroom observations, teacher interview transcripts, lesson documentation		Classroom observations, teacher interviews, class document analysis
Data coding Part 1		To identify emerging themes	Open coding
Data coding Part 2		To amalgamate similar coded categories	Comparison coding
Data display		To map themes emerging in the data against conceptual framework themes	Mapping of emerging data themes connected with geographical aims, pedagogy, GIS processes & place constructs against conceptual framework themes of pedagogy & place constructs
Data analysis		To describe teachers practice, place knowledge construction & pupils' interpretations of place	Thick description of data
Interim findings		To summarise interim findings	Summary of findings
Stage Three (Chapter 6)	Stage 3 Constructing the tsunami	Analysis of data set 3	
	Dataset 3 Classroom observations, pupil interview transcripts, lesson documentation	To map independent themes emerging in the data against my conceptual framework themes and data collected in stages 2 and 3	Participant classroom observations, teacher and pupil interviews, class document analysis
Data coding Part 1		To identify independent themes emerging in the data	Open coding
Data coding Part 2		To amalgamate similar coded categories	Comparison coding
Data display		To map independent themes emerging in the data against my conceptual themes	Mapping of emerging data themes connected with geographical aims, pedagogy, GIS processes & place constructs against conceptual framework themes of pedagogy & place constructs
Data analysis		To describe teachers practice, place knowledge construction & pupils' interpretations of place	Thick description of data
Interim findings		To summarise interim findings	Summary of findings
Discussion of overall findings	Datasets 1, 2 and 3 & conceptual analysis	To synthesise and discuss findings	Synthesis of findings Dialectical theory-building Discussion of data and conceptual themes in relation to the research questions Model
Overall conclusions	Datasets 1, 2 and 3 & conceptual analysis	To model findings	Final conclusions drawn Synoptic review Evaluation/Recommendations Recommendations for improvements & further research

**Figure 3.3 Analyses**

Figure 3.3 outlines the main elements of analyses. Each data set was coded as Figure 3.3 indicates. The indexing of topics allowed for collation and comparison of emerging themes across observations, interviews and journal extracts. The less frequently occurring themes were subsequently defined as sub-topics of the overarching themes of geographical aims, pedagogy, GIS and place constructs. In order to perform the constant comparison analysis, I scrutinized data and highlighted data for each theme. Each part of the data was assigned a code. Before a code was applied, earlier codes were checked to establish whether similar codes already existed (the comparison element of the analysis) and adapted accordingly (an abductive part of the coding process). Next, the codes were combined if

similar to reduce the number of categories that I was working with. Finally the emerging data themes of *geographical aims*, *pedagogy*, *GIS processes* and *place constructs* were mapped against my conceptual themes of *geographical integration*, *spatiality* and *pedagogy with GIS*. The latter were then used to inform the synthesis and discussion of findings discussed in Chapter 7 (Appendix A4 lists and exemplifies the coding process).

Data was collected and analysed using five main methods in the research:

- Interviews
- Classroom observations
- Research diary entries
- Document analysis
- Secondary analysis

The next sections examine each of these in turn.

### 3.4.1 Interviews

I chose to conduct semi-structured interviews in order to listen to participants' descriptions of their experiences of using GIS in the classroom. These types of interviews are designed to generate discussion and to maximise data collection within a limited research time frame. They are particularly useful for seeking views on an issue or description of an event. A combination of more closed and pen-ended questions are asked to encourage interviewees to describe an experience or to give their insights (Lankshear and Knobel, 2004) I chose to semi-structure the interviews to both steer our dialogue and give participants the opportunity to answer relatively freely (Merton & Kendall, cited in Cohen & Manion, 2004 p.274).. By this stage, I had become more aware that making the interview very structured seemed to limit our interchanges. Instead, I used the prompts as a general guide, whilst letting the conversation flow as freely as possible.

I carried out pilot studies for my interviews and as my experience of interviewing grew, I built in a 'funnel-approach' to the group interview, implementing minimal guiding to move participants from broader to more specific responses (Cohen and Manion, 1994). I adapted my interviewing style in response to this, aiming to create more of a 'conversational partnership' between us (Rubin and

Rubin, 2005, p 79). This proved much harder to execute than could have been expected. Though it would be unrealistic for me to claim that I fully achieved this, I can state with some confidence that piloting the interview process allowed me to move towards not dominating the interview process bias and to work more as facilitator in the conversations that unfolded. Put simply, practising to interview helped me to listen more carefully to the conversations that students had (Wilson, 1998). The semi-structured interviews included a list of pre-prepared questions which I used as a guide. I designed the interview format to include an introductory reference to my research purposes and some simple prompts linked directly to my research aims (Appendix A1). As a result, the interview design was aimed at eliciting a mix of fixed and open-ended responses. This approach allowed a level of flexibility for me to probe interviewee's responses and to prompt students to elaborate on key themes emerging in our conversations (Lankshear and Knobel, 2004). I also set out to evaluate the interview as it progressed, deciding to concentrate on these key elements associated with knowledge construction rather than others. My aim was to record the conversations as fully as possible but not lose sight of my main focus (Merton & Kendall, 1946).

There was an important limitation to this process. I had decided early on in the research that particularly in the case of the pupil interviews, recording pupils talking during lessons could be problematic. For a number of logistical reasons, I could not always guarantee a quiet, undisturbed location where interviews could take place. Whilst all interviews were conducted over an approximately 20 minute period at the end of a lesson, some were carried out in a relatively quiet office; others had to be conducted in the classroom where I was teaching. Coupled with this, some technical difficulties experienced with recording equipment in the pilot interviews concerned me with regards to obtaining full recordings. I had also carried out two earlier research projects where I had written responses as interviews progressed. Whilst the latter was not ideal, my compromise method was to immediately annotate responses directly after each interview. In retrospect, it could be argued that the benefits of accurate transcription outweigh the disadvantages of overcoming noise and technical issues. However, I am confident that my transcribing and then annotating student responses resulted in as accurate transcriptions as could be produced in the given circumstances.

### 3.4.2 Classroom observations

My central aim of understanding behaviour in context led me to choosing classroom observation as a key element of my data collection. Observation is considered to be one of the most effective forms of data collection in educational research because it entails the researcher 'being there' and reporting directly on the social situation in hand (Jones and Somekh, 2005). In their discussion about research methods, Denzin and Lincoln (2000) describe this type of approach as:

A situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them. (Denzin and Lincoln, 2000, p3)

Close scrutiny and record collection of processes occurring in the social situation at the focus of the research can allow for productive analysis of phenomena. However, social settings are complex and difficult to re-represent. Added to this, the subjective influence of the researcher observer led to at best a partial re-representation of what has occurred within the research setting. With these challenges in mind, choices about how to carry out and record observations inevitably result in compromises made around fitness for purpose of the approach chosen and the level of reliability of the data that can be achieved within a particular research setting. What is observed and how a phenomenon is observed depends to a great extent on how the observer 'sees the world' and her place within it (Jones and Somekh, 2005).

In this respect, my choice of participant observation at School B was based on a conundrum often experienced in practitioner research, that of the conflicting roles of being both practitioner and researcher. In all the lessons taught I was in the position of both teaching and observing. Though I argue that this placed me in an advantageous place to view what could be described as unique insights in to the behaviours and activities of students and allowed me, to a certain extent at least, to be 'absorbed into culture' of the classroom (Jones and Somekh, 2005); I cannot imply that this did not



prove both challenging and distracting at times. This was the compromise that I had to make in order to make use of observations as a worthy part of the data collected in the research. I took copious notes during the ten week period of teaching and am convinced enough that the value of what I observed. My research journal notes contain several detailed descriptions of cameos of student activity that I witnessed during these participant observations which are discussed in the data summaries at the end of Chapter 6.

### 3.4.3 Research journal entries

Journal entries give the researcher the opportunity to record observations and reflections both 'in the moment' and after research. The idea of immediate writing of a memo or other entry is seen as particularly vital in quickly flowing and changing turns of events in practitioner research (Bogdan and Biklen, 1982). The latter rang true in my experiences. I concluded early on in this research that writing in my journal as a precursor to more formal analysis of data was to become an essential part of both the schools-based research that is reported here but also in relation to on-going dialectical theory-building. My writing involved compiling memos which closely resembled what Bogdan and Biklen (2005) define as descriptive and interpretative sequences. Put simply, my diary entries contained descriptions of activities, one- of events and significant processes as I witnessed them in the classroom. Memos also included my interpretations of the latter, ranging from identifying these as significant in developing theory to much more tentative reflections and speculations about events unfolding in the research.

### 3.4.4 Document analysis

In each of the empirical stages I collected a range of documents to analyse. These included transcripts of interviews, teachers' written reports, project reports, teachers' lesson guidance and examples of pupils' work. Leech and Onwuegbuzie (2007) identify the strong link between how data is represented in research and the legitimization of research findings. In the research, four key data sources are represented: classroom observations, teacher and pupil interviews, research journal extracts, classroom documents. Figure 3.4 outlines the document analysis process.

### Figure 3.4 Document analysis process

1. Initial reading of document and allocation of open codes to emerging data themes



2. Comparison with conceptual themes/amalgamation of coding where appropriate and/or identification of separate independent theme



3. Researcher journal entry

Using the four sources allowed for a robust level of triangulation in terms of looking for replication of themes emerging from the four types of data.

#### 3.4.5 Secondary analysis

Secondary analysis is the use of primary data collected in the same research field to address new research questions ( Long-Sutehall, Sque and Addington-Hall, 2010; Hinds, Vogel and Clarke-Steffan, 1997). It is recommended good practice in secondary analysis that the research questions addressed are sufficiently similar to those applied in the primary research and that processes of data analysis are comparable (Heaton, 2004).

Secondary analysis can often reveal data which has either not been previously analysed or are closely related to secondary research questions (Long-Sutehall et al;2010). This proved to be the case in this research. The primary data from the 2006 primary study contained rich data on teachers' experiences of and views on teaching and learning with GIS in school geography and I judged that it could be used in a secondary analysis which could inform this thesis. The content of each teachers' responses in the primary dataset was assessed with regards to the two broad categories of geography curriculum outcomes and learning outcomes for pupils. As a result of this sorting process,

the final dataset used in the secondary analysis comprised of nine teacher interviews and their written reports which I judged could be used to address the first key research question in this thesis, namely: *How does GIS influence teacher practice?*

### 3.5 Ethical issues

Working with a range of institutions in this research has involved careful thought and planning about access to potential participants and establishing a research code of conduct if access is acquired. This research uses the British Educational Research Association guidelines (BERA, 2011). Before embarking on empirical study; I approached all institutions involved and acquired voluntary informed consent from potential participants. This involved my conducting the research with those involved being both fully and comfortably aware of the procedures and outcomes of my work with them. However, having already conducted two empirical studies as part of my MA Geography in Education (Fargher, 2004) and my MRes (Fargher, 2006), I was aware that this is not always as straightforward as simply requesting written consent. To fully explain my research I presented all participating institutions with documentation regarding voluntary informed consent and a detailed itinerary.

In compliance with accepted research norms and the Data Protection Act (1998), I provided written assurance that my findings would not include the names of any participating individuals or organisations. I was also fully aware that potential participants were under no obligation to become involved in my research. Even if an institution had agreed to become involved, I was aware that some pupils or teachers might not wish to participate (Bell, 1999). I was also aware that at any given time during my research, some individuals might wish to withdraw. Part of my research involved working with children and young adults. The design of my research methods complies with the relevant United Nations guidelines on working with young people (United Nations, 1989, Articles 3 & 12). Finally, I was aware of my professional responsibilities to colleagues and the wider research community. With this in mind, the empirical studies were designed to avoid bringing research into disrepute via falsification, misrepresentation or conflict of interest.

### 3.6 Conclusion

In the initial sections of this chapter I discussed how effective methodology reflects close links between theory and practice and to justify these in terms of their fitness for purpose. In this chapter I have examined closely ontological and epistemological assumptions and spelt out a conceptual framework which links these via *place constructs*, *pedagogy* and *dialectical theory-building* to the multi-stage case study/practitioner research design.

In acknowledging the perspectival nature of knowledge production, the chapter charted a number of approaches investigated during the course of this research including the measurement of cognitive load theory (CLT) and grounded theory methods (GTM). It made a case for a 'thick description approach' to methods of data collection and analyses in the research. It outlined iterative approaches designed with reciprocity and theory-building in mind (Lather, 1991). Figure 3.5 illustrates Lather's research interpretive frames which I have found useful in classifying my methods and which I use here to clarify these and to conclude the chapter.

**Figure 3.5** Research interpretive frames (from Lather, 1991)

Predict	Understand	Emancipate	Deconstruct
Positivism	Interpretive	Critical	Poststructural
	Naturalistic	Neo-Marxist	Postmodern
	Constructivist	Feminist	Post-paradigmatic diaspora
	Phenomenological	Praxis-oriented	
	Hermeneutic	Educative	
		Freirian participatory	
		Action Research	

In comparing Lather's interpretive frames with the methodological approaches laid out in this chapter, it is clear that this research rejects 'prediction' through 'positivism.' It displays elements of aiming to 'understand' the role of GIS in developing relational ideas of place. My seeking to look at *place constructs* and *pedagogy* takes the methodological route chosen here further towards a 'constructivist paradigm.' There are also distinct elements of embracing critical education theory and critical GIS (See Chapter 2 again for the theory which explicates this approach more fully). The research outcomes reported on in the practitioner research in Chapter 6 strongly reflect an 'emancipatory approach.' Most significantly, in terms of striving to resolve research aims, the 'rich description' gleaned through analysis of vignettes in that chapter, though not necessarily groundbreaking in terms of contributing to the field, the methods exhibited are 'educative.'

The contents page of this thesis provides clearly charts the order in which I have chosen to document the remaining chapters of the thesis. This chapter on methodology is followed by the empirical enquiries:

- Spatially speaking
- Mapping the land
- Constructing the tsunami

The empirical analyses are followed by two concluding chapters (Chapters 7 and 8). Chapter 7 identifies and discusses the main outcomes of the research and connects these with existing theory. Chapter 8 presents the main conclusions to be reached from the research, presents a model of geography knowledge construction based on the research findings, critically evaluates the research and makes recommendations for further investigation in the field.

## Chapter 4 Spatially Speaking

### 4.1 Introduction and background

This chapter reports on the case study research carried out with teachers involved in the second year of the GA's *Spatially Speaking* professional development project. It shows the impact of GIS on the geography practice of teachers from six UK schools. The chapter addresses the first research question most directly: *How does GIS influence geography teacher practice?*

*Spatially Speaking* was a 'Local Solutions' (LS) project developed by the Geographical Association and supported by ESRI UK and the British Educational Communications and Technology Agency (BECTA). The project investigated developing teacher GIS knowledge that could be used to enhance geography in education in schools. This involved a team of GIS teacher innovators and beginners from several different schools working together on developing pedagogical strategies around the use of the newest geo-technologies in the classroom. The project also drew on expertise and experience from other representatives of the GIS industry, teacher educators and educational researchers to investigate ways forward in using geo-technologies in the classroom. During the course of the project I was involved both as an advisor (2005-6) and as project evaluator (2006-7). My work with the project also informed my MRes dissertation (Fargher, 2006). Teachers involved in the project used ESRI software (ArcGIS) and online geobrowsers to develop their use of GIS. A key feature of the GA's Local Solution approach is to support motivated teachers in invigorating the curriculum, giving them professional support and time to work on developing their innovation (Mitchell, 2006). According to Sachs (2003), this approach is key in developing teachers 'transformative professionalism.'

### 4.2 Data collection

The semi-structured interview data and the analysis of teachers' reports on the project were collected in the primary MRes study (Fargher, 2006) and carried out in May and June of 2006 after teachers had completed their school-based action research. The teachers written reports were completed in the July and August of the same year. During the MRes study, I used X Sight research software to create a database containing transcripts from teacher interviews, and their written project reports.

Entries were divided into two groups: experienced and less experienced GIS users. In that primary analysis I identified and explored a number of key themes in relation to the main research question in that study identified above. Teachers were asked to comment on the following:

- Benefits of taking part in the project
- Barriers to their progress in using GIS
- Specific issues experienced and exemplified
- Recommendations for future use of GIS

Teachers were also asked to comment on their geography curriculum development with GIS and their pupils' geographical learning outcomes. In order to provide further background context on the original 2006 primary dataset, Figure 1 summarises the type of school and level of GIS experience of the nine participants surveyed in 2006 and included in this secondary data analysis.

**Figure 4.1** Overview of Spatially Speaking teachers

<b>Teachers</b>	<b>School Sector</b>	<b>GIS Experience</b>
1. David	Independent	Experienced user
2. Jenny and Marco	State Comprehensive	New users
3. Mike and Simon	Grammar	Experienced users
4. Eleanor	State Comprehensive	New user
5. Sandra and Julie	State Comprehensive	New users
6. John	Independent	Experienced user

#### 4.3 Procedures of analysis

This section outlines the ways in which the data was analysed. Part of my aim in investigating the role of GIS in constructing knowledge in geography education involved my wanting to use the knowledge of teachers involved in the Spatially Speaking project to inform the later stages of this research which is more specifically geared towards analysing place knowledge construction (See Chapters 5 and 6). With this intention in mind, listening to Spatially Speaking teachers report on their

experiences of action research on curriculum innovation with GIS became an important source of evidence to inform the research as a whole. These data were originally identified in the primary dataset and grouped according to whether they referred to curriculum outcomes or learning outcomes for pupils. In the 2006 study teachers had been asked to recount the benefits, barriers and examples of specific issues that they had experienced as a result of being part of a 'Local Solutions' CPD project and to make recommendations for future CPD with GIS in geography education.

As part of that initial survey, they were also asked to identify and describe specific curriculum development that they had carried out in their school with GIS. They were also asked to identify specific geography learning outcomes for their pupils. In the initial sorting procedure for the secondary analysis which forms the basis of discussion in this chapter, I returned to that dataset in XSight, with the literature review conceptual themes identified in Chapter 2 in mind. These were:

- Using GIS to develop pupils spatial literacy
- synthesis in relational thinking
- integration in GIS spatial processing
- enquiry learning through GIS
- limits to geographical representation in GIS
- the role of contemporary GIS
- challenges of using GIS

The primary data from the 2006 study was then analysed through a process of coding whereby I initially annotated the database where instances of each of the conceptual categories were present. Figure 4.2 summarises the procedures of analysis followed.



**Figure 4.2** Procedures of analysis

Analysis	Data		Procedure	Function
Data sets	Interviews	Written Reports		
Data coding 1	✓	✓	First level coding	To identify initial data categories
Data coding 2	✓	✓	Pattern coding	To amalgamate similarly coded categories
Data display 1	✓		Summary matrix	To identify themes emerging from the data
Data display 2	✓		Teacher outline of practice drawn	To identify themes for individual teachers and across teacher groups
Summary and Conclusions	✓		Summary Conclusions Drawn	To summarise findings and outline contribution of the chapter to the overall research

As Figure 4.2 illustrates, the analysis of data took place in a number of stages. First, all the data (teacher interview transcripts and written reports) were read and I annotated them with preliminary categories. In the second stage of the analysis, similarly categorised data were subsumed. In the third stage, a summary matrix was drawn in order to display the main themes emerging from the data for each teacher (or pairs of teachers). In the next stage, the data was mapped for individual teachers (or pairs of teachers if working together in the same school) to display their individual practice with greater clarity. The evidence in the database revealed that all 9 of the interview transcripts in the primary data set contained a range of data which had what I judged to be direct relevance to the first research question which this research seeks to address, namely: *How does GIS influence teacher practice?* The main analytical themes identified from the data were used to structure the discussion of main findings that follow in the remaining sections of this chapter. The next section describes the six school cases in turn. The data for each school is divided into the four analytical themes identified. These were:

- geographical aims
- processes of knowledge construction
- teaching outcomes
- learning outcomes

Included in the description of each case is an outline which summarises the main features of teachers' reported practice.

#### 4.4 Results of analyses- David

At the time of the Spatially Speaking project, David was a head of geography at a public school in Bedfordshire. He had already gained considerable experience in using GIS prior to joining the project and ran INSET for teachers on using GIS in school geography. As a result, David is categorised for the purpose of this research as an *expert GIS user*.

##### 4.4.1 Geographical aims

In both his interview and final written report, David identified two main aims of using GIS for geography: to visualise geographical patterns and to use the technology to link sets of spatially-referenced data together. David described how these two elements can work together in a number of ways:

*This is the sort of classroom which promotes learning which stretches far beyond its four walls. Pupils can be challenged to address real world local landscape management issues. Why not have students working with the Local Authority – mapping graffiti-prone sites, determining the best position for a skate park, identifying potential trip hazards on footpaths, the possibilities are endless. (David)*

David's emphasis was on pupils using GIS tools to access 'real world data' and to display and analyse their findings.

##### 4.4.2 Processes of knowledge construction

David described the processes that he followed with his pupils in using GIS to collect, display and analyse spatially-referenced data. This approach was reflected in the examples of practice which David described. He remarked on how his A Level students use mobile GIS to collect and measure weather data:

*Senior student projects have located sites for examination of urban heat islands by connecting instruments to measure atmospheric conditions [through mobile GIS]. With the software installed, the base map copied from the PC to the mobile GIS and GPS operational, pupils can be let loose on an unsuspecting local area. Walking to pre-determined positions, if they wish, readings can be taken quickly and easily. (David)*

David explained how data collected outside the classroom could be brought back to school and transferred to a full GIS computer programme. He noted how this process of integrating fieldwork data then allowed pupils to display geographical patterns and analyse them:

*Back in the computer room, data is downloaded and mapped using the full-blown version of the GIS software. Here patterns can be examined and quantified. For example, Arc Map can be used to calculate a Nearest Neighbour Analysis of various business activities within the CBD defining the degree of clustering and dispersion. (David)*

David also described how Year 9 pupils carried out environmental surveys and studied pedestrian flows using similar mobile GIS:

*With Year 9 students, we have mapped how Environmental Quality varies around the town and then evaluated this data in relation to traditional land use models. Other groups have mapped pedestrian flows throughout the CBD. (David)*

#### 4.4.3 Teaching outcomes

With regards to managing teaching and learning with GIS, David held the clear view that using GIS required a shift in pedagogical practice away from didactic teaching and more towards pupil-based enquiry learning. He explained how this kind of pupil-centred work involved a change in practice for teachers:

*GIS as a tool is not an end in itself. [It involves teaching being] less directed by the teacher and more enquiry - constructivism. Colleagues and pupils pulling together. Pedagogy is really the next step. (David)*

David expanded on exactly what he thought about implications for future teacher practice with GIS:

*'Working with students in this fashion requires a fundamental change in our classroom approach. The teacher is no longer the centre of attention in the traditional sense; the 'teacher' becomes the 'facilitator of [pupil-centred] learning. (David)*

#### 4.4.4 Learning outcomes

David identified a number of key reasons for using GIS to promote his pupils learning in geography. Whilst he appreciated the technical capacity of mobile GIS to collect and display spatial data, David believed that using this type of technology supports geography learning on a number of levels:

*Whilst some might argue that the use of mobile GIS [with pupils] is an end in itself, I feel GIS is merely a tool to aid learning. And this learning takes place at a number of levels: the ability to work within a team, the use of technology, project management, high level cartography and presentation skills, spatial analysis, report writing....at this point it is interesting to remind ourselves we are talking about school pupils here, and the skills being promoted are skills they will use throughout their life. This is the sort of classroom which promotes learning which stretches far beyond its four walls. Pupils can be challenged to address real world local landscape management issues. (David)*

David commented on the value of using mobile GIS in promoting pupil's independent learning:

*Mobile GIS is a brilliant way to engage students in their learning by promoting the use of technology in the field and challenging them to design projects which are of significance to them .The integration of GIS within geography classrooms is one important way geography can arrest declining numbers and a tendency for the subject to be amalgamated within social studies. (David)*

David identified another benefit of using spatial data in GIS to support pupils' analyses of spatial patterns particularly through mapping:

*Quality of the output greatly enhances their motivation in writing reports and so on – maps can be cut and pasted into their documents to illustrate various points. (David)*

#### 4.4.5 Summary

David used GIS to support geography teaching and learning for two main reasons: to visualise geographical patterns and to use GIS to link spatially-referenced data sets. David used GIS in geography in a number of ways but particularly to link field work with class work. Pupils in David's classes used GIS to collect fieldwork data, to measure atmospheric conditions and to carry out environmental and land use surveys. In the classroom, David's pupils mapped and analysed pedestrian flows and carried out statistical procedures such as nearest neighbour analysis. David emphasised that an enquiry approach is essential in his teaching with GIS. Figure 4.3 summarises David's GIS practice.

**Figure 4.3** Outline of GIS practice - David

<p><b>Geographical aims</b></p> <ul style="list-style-type: none"><li>To visualise spatial patterns</li><li>To link spatially-referenced geographical data sets</li><li>To link fieldwork with classwork</li></ul>	<p><b>Processes of knowledge construction</b></p> <ul style="list-style-type: none"><li>Measuring atmospheric conditions</li><li>Mapping pedestrian flows</li><li>Linking field and classroom data sets</li><li>Land use mapping</li></ul>
<p><b>Teaching outcomes</b></p> <ul style="list-style-type: none"><li>Less didactic role</li><li>Teacher as facilitator</li></ul>	<p><b>Learning outcomes</b></p> <ul style="list-style-type: none"><li>Enquiry learning</li><li>Studying real world issues</li><li>High quality cartography</li><li>Spatial analysis</li><li>Evidence-based decision-making</li></ul>

#### 4.5 Results of analyses- Jenny and Marco

When the project began in September 2005, Jenny and Marco were both working at the same state comprehensive in Bedfordshire. Jenny, the head of her department, had very little GIS experience at that time. Marco on the other hand had worked with ArcGIS as a town planner in a previous career but had no experience of using GIS in the classroom prior to joining the project. Jenny and Marco were categorised as 'new GIS users' for the purpose of this research.

##### 4.5.1 Geographical aims

Jenny described how as a geography teacher and curriculum leader she had been aware of the possible advantages of using GIS to support teaching and learning for some time. Both Jenny and Marco indicated that using GIS to visualise spatial patterns was their main aim in using it in geography. Marco summarised this perceived advantage of GIS in response to this rhetorical question:

*Is GIS helpful for the teaching of Geography? Without a shadow of doubt. It is visual and as it is often said: a picture is worth a thousand words'. (Marco)*

Both Jenny and Marco expressed their keenness to develop their pupils' spatial skills through GIS particularly because of the potential relevance to the world of work. They both indicated that enhancing local fieldwork through GIS was a big priority in their department. Most of all, both discussed using GIS to generate geographical data that their pupils used to make informed opinions. Marco described GIS as:

*A superb tool to display patterns and trends. It facilitates decision-making and it is out there in our everyday life, even if we don't realise it. We must prepare children for the future, making [them] GIS literate is an important part of this process 'Geography is about being able to make informed decisions and GIS provides the tools to make those informed decisions.(Marco)*

#### 4.5.2 Processes of knowledge construction

Jenny and Marco explained how they used online GIS sites to introduce the basic concepts of GIS to their pupils. As Jenny described the progress that they had made with using GIS to support map work in Year 7 Geography, it was online GIS that continued to enthuse them, partly because it circumvented the technical issues that she also describes about installation of GIS software

*Using the Durham GIS website we designed the task (shown in our presentation). This planning activity required the use of GIS. Some of the basics of GIS were introduced to assist with the planning. We have designed and trialled GIS based activities with Year 7 which can be used in other year groups as well. (Jenny)*

Jenny described how financial help from the Spatially Speaking project had helped in their pursuing the web-based GIS route further

*Having been much encouraged with our progress of using free-viewers we were keen to further develop our skills in the use of GIS and the knowledge and skills of our learners. We were particularly keen to find locally-based GI to make GIS even more relevant to our learners. (Jenny)*

Jenny wrote enthusiastically in her end of project report about how delighted the department were when they eventually found some local GI data that could be more relevant to their pupils and came fairly ready-to-use:

*The Observatory' site – a service provided by the Borough Council providing Census data, local statistics, population and household information, data on service provision and Quality of Life indicators. We were excited to find that such information was readily available for us to use. (Jenny)*

Jenny's comments on the final stages of curriculum development with GIS were made after Marco's departure to take up a new teaching post. She elaborated here on how she and Helen (her new member of staff) now built on the GIS practice that she and Marco had established earlier in the project:

*With our new gained knowledge we set out to develop classroom resources to use in conjunction with the local material. We came up with various ideas from looking to find the best routes to the football ground to finding the best location for a new doctors' surgery or sports centre. We finally focused on an activity that learners, in the guise of Estate Agents, would use the information and maps on the site to determine the best new home for their clients. We called it 'Home Sweet Home. (Jenny)*

#### 4.5.3 Teaching outcomes

Jenny gave examples of how the department had begun to build differentiation into their lessons with GIS:

*Our learners were put into mixed groups which allowed for much peer motivation with youngsters keen to support each other. As the task was mainly computer-based, we felt that lower ability children would find this activity easily accessible. When it came to the analysis of the properties the higher ability children were more able to understand the links between places and were more logical in their thinking. They produced more accurate accounts of the various wards and through their ability of manipulating the data were able to support their work with stronger arguments. (Jenny)*

Marco discussed how the department adapted to and overcame their initial difficulties with using ArcGIS9. In particular, through gaining access to local authority data:

*When I started we had little knowledge ourselves about GIS – although I had slightly more given my prior background in spatial planning. During my time at the school we developed some materials and tried to overcome the challenges posed by technical difficulties and a lack of data. We quickly realized that what should have been a very simple process would in practice involve a series of protracted exchanges with the local authority in order to receive the correct sets of data. (Marco)*

Marco also identified the next stage for them to develop in their teaching with GIS:

*Next we want to focus on the pedagogy – the How? What? Why? The spatial awareness and what does this potentially hold for geography – we want to demystify GIS. (Marco)*



#### 4.5.4 Learning outcomes

Jenny described how they had developed their online use of GIS for pupils:

*Our main outcome was introducing our learners to the main ideas and basic skills of GIS through an activity whereby learners had to use the internet and the Durham City Council GIS site to plan a weekend-long trip from our town to Durham. Learners were encouraged to find their own GI to assist them in route-finding, activity planning and were taught the main precepts of GIS in general. (Jenny)*

Jenny elaborated on using the Durham GIS website as a model of good GIS practice had helped the department to develop their curriculum using more locally-based resources. Jenny elaborated on the enthusiasm for GIS that she witnessed throughout this activity:

*In general our learners were highly motivated throughout this activity and as always put our own skills to shame. They constantly surprise us with their insight and the speed in which they pick up new ideas and run with them. (Jenny)*

Jenny commented on the value that her department placed on using different levels of GIS activities to structure planning for progression:

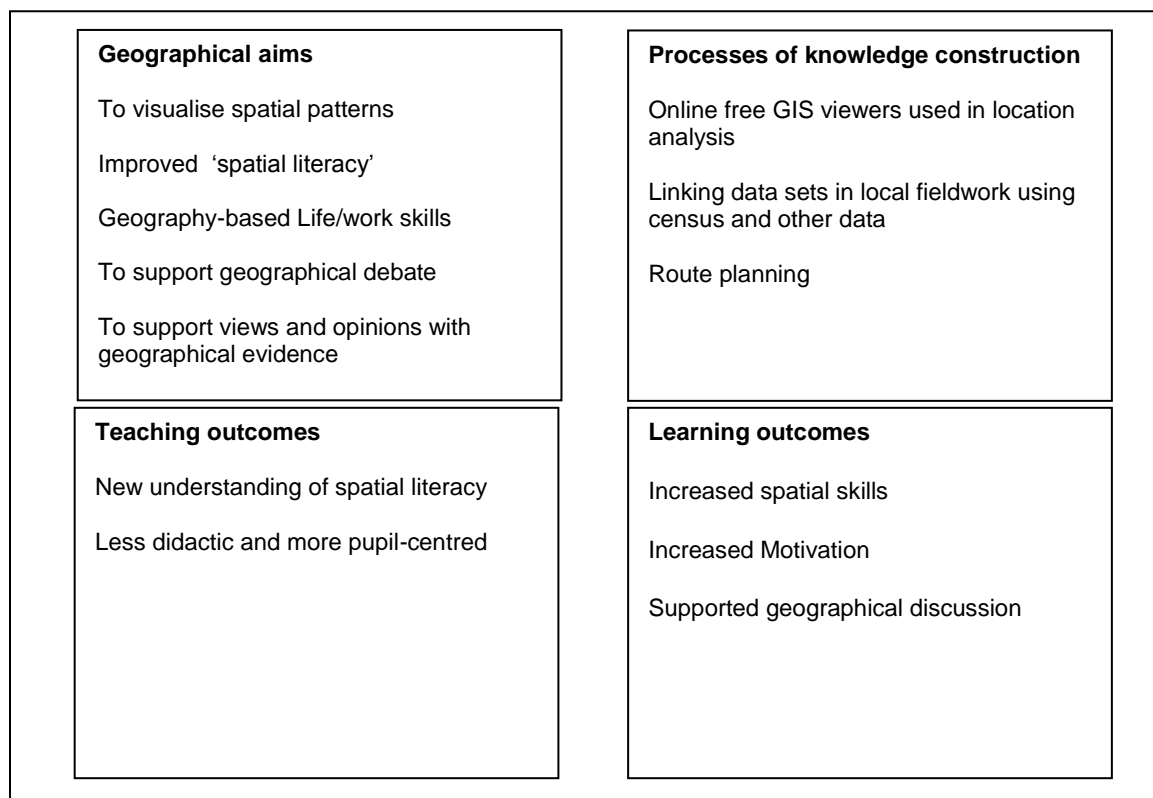
*We found this activity to be the perfect progression for our learners from last year's task. We feel that it has also provided for our learners a further understanding of GIS and could be considered a building block for them producing their own maps with the use of GIS. We would see this as the next stage in our work with GIS in schools.(Jenny)*

#### 4.5.5 Summary

Jenny and Marco used online GIS in their geography teaching and learning. They used GIS to display spatial data that their pupils can use to support discussion in their geography. Though they experienced difficulties in using more technical GIS such as ArcGIS, they developed the use of online GIS to support their geography curriculum in a number of significant ways. In particular they developed local fieldwork studies via the use of local council data. Pupils at their school used a number of other online GIS sites to carry out route planning and location analysis. Jenny

and Marco noted the motivational benefits of their pupils using online data and real world work skills.

**Figure 4.4** Outline of GIS Practice – Jenny & Marco



#### 4.6 Results of Analyses - Mike and Simon

Mike and Simon were based at a large grammar school in one of the largest cities in Yorkshire. Mike had previously worked in industry but had re-trained 5 years prior to becoming a geography teacher at the school. Simon was not a geographer but held the post of Head of Biology at the school. Both Mike and Simon had a great deal of experience in using GIS prior to the project. Also, both were seconded for a day a week to develop school-based GIS resources with ESRI (the GIS company that was jointly sponsoring the Spatially Speaking project). For these reasons Mike and Simon were categorised as 'expert GIS users' for the purpose of this research.

##### 4.6.1 Geographical aims

Mike and Simon identified a number of clear aims for using GIS in their geography teaching and learning. In particular, they used GIS to help their pupils visualise spatial patterns, process data

and support higher level geographical thinking. Mike described the value of his pupils making geographical connections in GIS:

*Correlations are immediately and visually evident so they [the pupils] often 'get it' straight away. It lets them see the patterns for themselves e.g. with the spread of disease – they look for the reasons and they see that the spatial pattern is the key. (Mike)*

Mike also reported further on the specific implications of enhancing pupil's geographical learning through integrating a range of digital data in a GIS:

*Creating innovative learning relevant to the world in which our students live and will ultimately work is a daily challenge for all teachers. Over time a wide variety of resources such as TV, video and interactive software, DVD and the internet have all been employed to engage students and enable them to interact with 'real world' scenarios.(Mike)*

In their written report, Mike and Simon discussed the precise value they place on using GIS to analyse spatial data in geography and other school subjects:

*The one thing all these topics have in common is that they involve the presentation and analysis of spatial data and this is exactly what a GIS does extremely effectively, and not just in Geography lessons.(Mike & Simon)*

Mike and Simon summarised their main aims for using GIS geographical learning in a number of ways:

*Our aim in using GIS remains the same. We are keen for our pupils to experience the kinds of technology used in real world situations but we are especially keen to provoke them to think analytically about the data they are manipulating. GIS software is simply one of a range of teaching devices to facilitate this but with the clear motivational benefits that derive from the hands on use of an impressive contemporary technology. The particular advantage offered by GIS when collecting and interpreting field data is the ability of the software to process and visualise raw data rapidly to enable immediate and critical discussion of the results. (Mike & Simon)*

Mike described the advantages of geography teachers using GIS to collect and analyse spatial data particularly via internet access:

*Geography has embraced these with great effect, however not until now has a tool been available which allows all of these elements to be combined and applied using the real world as the data source. (Mike)*

#### 4.6.2 Processes of knowledge construction

Mike and Simon identified a number of significant ways in which GIS was used to construct knowledge in Geography and other subjects in his school. In Geography, GIS was a key feature of teaching and learning across the year groups:

*In Year 7, pupils use GIS to study the world map, particularly latitude, longitude and time. Years 8 and 9 pupils study Brazil and Tectonics through GIS. Year 10 and 11 do fieldwork on CBD land use and study alternative energy. Year 12 use GIS to study hurricanes. (Mike & Simon)*

Mike and Simon described the benefits of being able to link geography-related data together through GIS. In their written report, they exemplified these benefits:

*GIS may be a computer-based tool for mapping and analysing features and events, but when the software is an integrated package enabling direct access to the internet, or links to databases and PowerPoint presentations, and when video is embedded into maps and diagrams of spatial data, 'real world' learning takes on a whole new dimension. (Mike & Simon)*

Mike discussed the pedagogical advantages experienced through connecting class work and fieldwork in a similar way:

*We have been using ESRI's ArcGIS across the school network for the last three years, so our software of choice for mobile GIS was ArcPad which is designed to run on a PDA and is fully compatible with the parent software. The work was all carried out using ArcGIS 9.1 together with ArcPad 7.0. This combination enables files for collecting field data to be created on a PC by either pupil or teacher, transferred to the PDA, edited in the field by pupils and then returned to the PC for further work in the classroom. (Mike)*

Mike and Simon also described how they used mobile GIS to support field work further in a number of ways:

*We developed three different field activities, one investigating land use in a small settlement specifically for Geography, one on the use of lichens as indicators to assess air quality specifically for Biology, and a third for collecting and visualising air temperature data which could be adapted for fieldwork in either subject. The particular example we tried out was investigating the microclimate around the school buildings.  
(Mike & Simon)*

They explained how a range of GIS applications allowed them to integrate data from fieldwork back in the classroom:

*Our example was based on Grassington, a small Dales village. An existing paper map of the village was digitised and a data capture form created in ArcPad so that each building could be assigned codes simply by tapping each building and choosing from customised drop down menus whilst walking around the streets.(Mike and Simon)*

Mike and Simon discussed the specific advantages for pupils being able to map land use as they moved from site to site:

*This is the digital equivalent of pupils walking around with a clipboard, except that on return to the classroom, the task of creating land use maps for subsequent discussion is greatly speeded up by using the facilities of the desktop GIS. Collecting point data of various sorts is common to many fieldwork situations. (Mike & Simon)*

In their written report, Mike and Simon described similar advantages experienced through GIS use in Biology fieldwork:

*Using lichens that are able to survive in different areas as indicators of air quality are an example of fieldwork that is greatly enhanced by using GIS. Plotting the results in terms of different zones of air quality is difficult using paper based methods. However, data*

*captured across a wide area using a PDA can be returned to the GIS and, by using ESRI's Spatial Analyst extension, can be visualised as different coloured zones representing varying sulphur dioxide concentrations.*

*(Mike & Simon)*

Mike and Simon also discussed how they used GIS to study microclimates around the school. They described the advantages of pupils being able to use handheld devices to link GPS locations and weather measurements in their field work:

*Our third field activity investigates the microclimate around our school buildings. Using a simple base map of the buildings, it is possible to tap a point on the map, such as the corner of a building, when a temperature recording is required. Alternatively, ArcPad can record the data at the point indicated by the integral GPS. Tapping on the map brings up a data capture window and the pupil simply types in the value obtained from the digital thermometer. (Mike and Simon)*

Mike and Simon discussed the benefits of having measured data in the field and returning to school to map and analyse findings:

*On return to the classroom, these values can be used to produce a thermal map of the school site. Exactly the same approach could be used to record pedestrian counts in a shopping centre, traffic counts in the streets surrounding a school, or soil moisture readings in a wet meadow. (Mike & Simon)*

Mike and Simon explained that although processing data was an intricate procedure, the quality of presentation and analysis by pupils was very valuable for the discussion of their findings. Simon described the ways in which he has plotted plant distributions through GIS in this way:

*The data is entered on the PDA using customised forms created for ArcPad. When the recording point is tapped on the base map, all the lichen species that pupils might have found are brought up as a series of images from which they can select. The highest sulphur dioxide concentration that can be tolerated by that species is then selected from a second drop down menu. (Simon)*

Simon's description also indicated that pupils were able to display photographs of sites visited before analysis:

*The concentration data associated with each point can then be used to produce a surface overlaid on the base map and any apparent spatial patterns in air quality can then be discussed, including the assumptions made by the software in presenting the data and consequent shortcomings of the visual presentation. (Simon)*

Simon also described how pupils produced layers of information in their maps which integrated a range of data collected.

#### 4.6.3 Teaching outcomes

Mike and Simon described the ways in which they introduced GIS into the curriculum. Pupils were led through the ways in which GIS displays data and how they to 'read' patterns with their teacher modelling GIS analysis:

*Pupils first encounter GIS in Year 7 in History and Religious Studies, used as a teaching tool with teacher-led activity on a whiteboard. They then gain hands on experience in Year 8 in Biology before encountering more frequent GIS in Geography in Years 8 and 9. Geography pupils then use GIS in their GCSE project work. (Simon)*

In their written report, Mike and Simon exemplified the benefits of using GIS technology to link a wide range of maps and other diagrams to display data with their older pupils. By this stage in their school career, they explained, pupils were well-versed in interpreting spatial patterns in GIS:

*Further materials under development include looking at patterns of heart disease and lifestyle risk factors across the UK in Biology, predicting ideal business locations for A Level Business Studies and looking at air pollution in Chemistry. (Mike & Simon)*

Mike and Simon explained how geographical thinking alongside GIS methods in fieldwork had been introduced into other subject areas in their school:

*Last year we concentrated on encouraging several different curriculum areas to try out and develop GIS based lessons. Continuing the cross curricular approach, we have used a second year of support from the Spatially Speaking project to look at ways of bringing field data into our GIS. As we indicated in our first report, Geography may be the natural starting point for introducing GIS, but thinking beyond Geography can be beneficial when introducing GIS into a school. In the case of fieldwork, there are equally obvious applications for handheld GIS in Biology, as well as in Geography (Mike & Simon)*

Mike and Simon emphasised that they see spatial processing as the cornerstone of what GIS is used for in their school. They explained how valuable the use of spatially-referenced data had been in other subjects:

*Looking at patterns of heart disease and lifestyle risk factors across the UK in Biology, predicting ideal business locations for A Level Business Studies and looking at air pollution in Chemistry. The one thing all these topics have in common is that they involve the presentation and analysis of spatial data and this is exactly what a GIS does extremely effectively.(Mike & Simon)*

Mike and Simon described how they have developed curriculum planning with teachers beyond their own school:

*Collecting raw data onto simple base maps is also an accessible way to begin to use GIS with the added bonus that it sidesteps the initial problem of finding suitable data in usable form by generating it from scratch. Continuing our outreach to a group of local schools, we used this idea as the basis for a training session for some local Geography departments, where we showed how a simple outline map of the school grounds or local shopping centre could be used to collect and analyse point data in a GIS. (Mike & Simon)*

Mike and Simon also discussed how their experiences of using GIS in local field work could also be used in a number of ways by teachers:



*Many Geography departments have a local shopping centre or favourite small settlement where they routinely carry out a land use field survey. This is an ideal candidate for converting to a mobile GIS based activity. Existing paper maps that may have been used by a department for years can be scanned and loaded into the GIS as an image. This avoids the need for OS map data, although such data can of course be used if available. The resulting layer does not necessarily need to be geo-referenced, especially if the buildings are simply going to be coded for various categories of land use. (Mike & Simon)*

Mike and Simon acknowledged that GIS processing of data requires a high level of skill and critical consideration by teachers but brings a number of advantages for teaching about geographical distributions:

*Designing the most appropriate data capture forms for pupils to use is the key to successful field data collection using mobile GIS. Once this is achieved, the techniques described here could be adapted for a whole variety of possible field activities, allowing rapid data visualisation for class discussion. (Mike)*

#### 4.6.4 Learning outcomes

As their identified key aims suggested, Mike and Simon valued the use of GIS to collect and display spatially-referenced data. They identified that a key purpose of using GIS was to provide their pupils with the means to support their geographical reasoning with evidence. Mike described an example of this kind of application in their A Level classes:

*Our Year 12s use neighbourhood statistics [in their analysis] so much more easily. It has really contributed to higher level analysis and debate [at A Level]. (Mike)*

Simon described associated benefits of GIS for wider learning in schools:

*Like other software applications such as Word or Excel, GIS provides pupils with opportunities to use a variety of skills and to enhance their competency in areas such as literacy, numeracy and working with others. (Simon)*

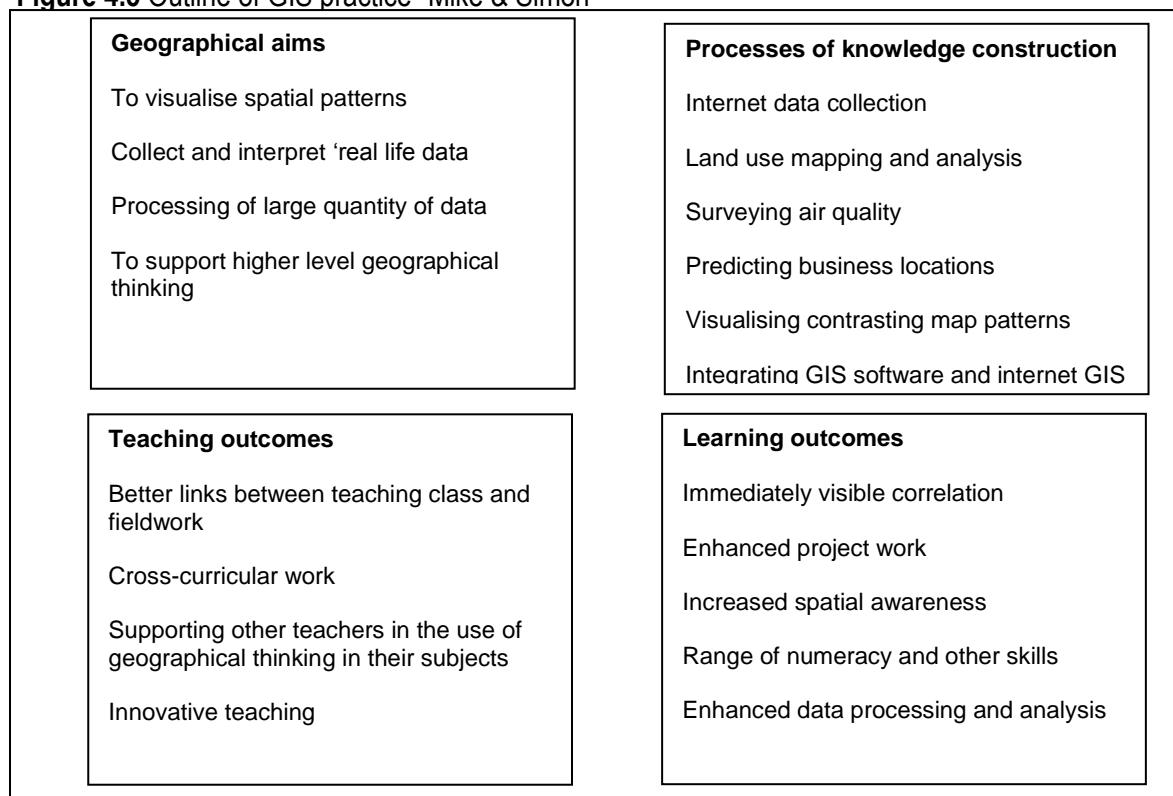
Mike commented on the ways in which pupils were able to build on their GIS experiences and to develop the quality of their enquiry-learning as they progressed through the school:

*There is clear differentiation over the three years of their GCSE [project] work where quality of content, presentation and data analysis improved. (Mike)*

#### 4.6.5 Summary

Mike and Simon identified a number of key areas in their curriculum development with GIS. Their main aims for using GIS were to enable pupils to see spatial patterns for themselves and to look for the geographical reasons behind these. Both indicated that using data collected and analysed through GIS promoted higher level geographical thinking. Mike and Simon also described curriculum development using live data from the internet to study a range of geographical phenomena. They also both noted that using GIS has the advantages of being able to process large amounts of data quickly. Mike and Simon reported that being able to integrate desktop GIS with online GIS was both innovative for their curriculum development and motivating for their pupils.

**Figure 4.5** Outline of GIS practice- Mike & Simon



## 4.7 Results of Analyses – Eleanor

Eleanor, though relatively new to using GIS in the classroom, was in the unusual position of having had a sabbatical experience with a university geography department working with GIS. One of her more recent areas of curriculum development also involved working with the Dakini GIS project, an Anglo-French based project for secondary schools which provided online access to a range of Ordnance Survey and satellite data. For the purpose of this research, Eleanor was categorised as having had *some experience of using GIS*.

### 4.7.1 Geographical aims

Eleanor described a number of key aims of using GIS in geography. She was particularly committed to using GIS to connect and display geographical data. She traced her interest in using GIS in the geography curriculum back to a conference she attended earlier in her teaching career:

*I first came across the three letter acronym, GIS at a conference when it was demonstrated as the geographic tool of the future. It seemed that, given a set of data, it could create at the press of a button a whole range of maps and could demonstrate spatial relationships.*  
(Eleanor)

Eleanor articulated her enthusiasm for GIS very clearly. She explained that she had a strong rationale for using GIS in her department. In essence, she wanted to capitalise on the processing power of GIS to give her pupils access to a range of geo-visual data. She described how she felt after attending the conference:

*I was impressed: I would introduce this tool into schemes of work across the secondary geography curriculum, highlighting the importance of the subject in investigating social and physical issues. My students would be invaluable in the workplace, their work would be much sought after as they conjured up with ease maps showing deprivation, flood risk and crime hotspots.* (Eleanor)

#### 4.7.2 Processes of knowledge construction

Eleanor described how she used GIS to help her pupils construct geographical knowledge and to support decisions made through geographical enquiry:

*GIS brings maps back to Geography and isn't Geography about maps anyway? Geography is about being able to make informed decisions and GIS provides the tools to make those informed decisions. (Eleanor)*

Eleanor explained how her department used local Ordnance Survey maps as part of the Dakini GIS project that she was involved in previously:

*We have used local Ordnance Survey Maps in Kent as part of the Dakini Schools Project .Our local OS liaison officer at Kent county council has supplied us with super OS grids for fieldwork and 1:10000, 1:25000, 150,000 digital maps. 'We're also using the Magic Interactive Environmental Mapping website with our Year 7 classes and the USGS tectonics site. (Eleanor)*

#### 4.7.3 Teaching outcomes

Eleanor noted that being able to use digital maps in her teaching, particularly local Ordnance Survey maps helped her to support project work at GCSE. She recognised the need to develop her own GIS knowledge before she could use Arc GIS in the classroom in the ways that she described:

*Before I can deliver such lessons in the classroom, I first have to become more familiar with the techniques of GIS myself and decide upon which of the commercially available packages to choose. (Eleanor)*

Eleanor developed this point further by highlighting the advantages for geography teaching and learning of being able to use GIS to display spatial data coupled with the need for appropriate training for teachers:

*GIS is the geography tool of the future – where you can press a button for spatial relationships. But with that is the reality of following the basics of GIS. We need 'using it or losing it training.' (Eleanor)*

Eleanor identified that she and her department have developed more confidence in using GIS but still need to work from menu-led lists of instructions:

*Now we are much more confident (with GIS). But we need ready-to-use resources. An idiot's guide. 11 pages of instructions but the kids press buttons straight away when it's menu-led. (Eleanor)*

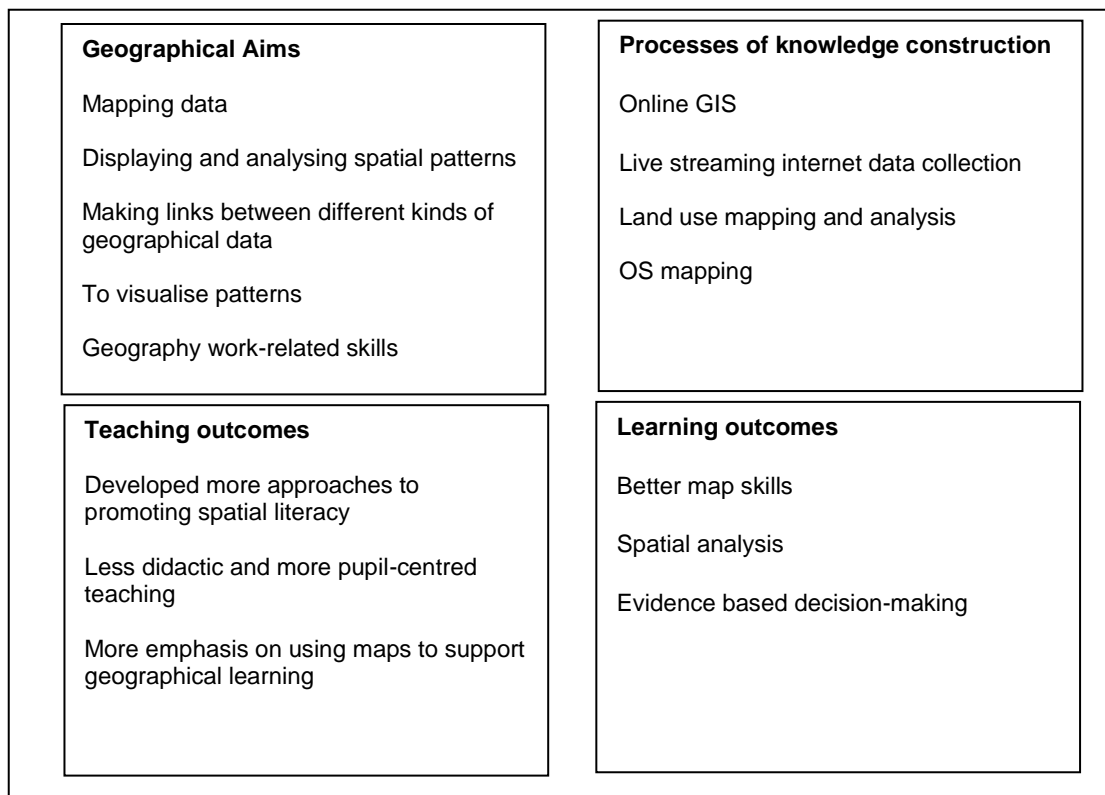
#### 4.7.4 Learning outcomes

Eleanor identified the improvement of map skills through her pupil's use of GIS and their use of internet maps. Her pupils also learnt how to use online environmental maps to study environmental quality patterns in their local area.

#### 4.7.5 Summary

Eleanor described a number of key areas in her curriculum development with GIS. Her main aims for using GIS were to enable pupils to visualise spatial patterns and to map these through GIS. She indicated that using data collected and analysed through GIS promoted better geographical understanding amongst her pupils. Eleanor described the challenges met by using GIS including the need to provide on-going training for teachers.

**Figure 4.6** Outline of GIS practice- Eleanor



## 4.8 Results of Analyses - Sandra and Julie

At the time of the project, Sandra and Julie were based at a large, newly-built state comprehensive in Essex. Both had some experience of using GIS before joining Spatially Speaking. In particular they had worked with a GIS consultant on producing local fieldwork maps. For these reasons, Sandra and Julie were categorised as having had 'some experience of using GIS' for the purposes of this research.

### 4.8.1 Geographical aims

Sandra and Julie had clear aims for developing geography through GIS with their Gifted and Talented pupils. Their focus in curriculum development was on supporting local field work particularly through mapping. Sandra and Julie were also keen to simplify the use of GIS for themselves and their pupils. They identified that this was a geographical aim that when achieved helped to strengthen both teaching and learning.

### 4.8.2 Processes of knowledge construction

Sandra and Julie described how they began with basic GIS concepts to map data via internet GIS through PowerPoint:

*We began working with the concepts associated with GIS by using PowerPoint to trace maps and add information using symbols and hyperlinks. The pupils really engaged with these and it was valuable. (Sandra & Julie)*

Sandra and Julie also used simple online GIS sites such as the Ordnance Survey's GIS Zone to introduce their students to further examples of GIS in practice:

*We also used some of the GIS based activities on the Ordnance Survey website although we found that these needed extra materials to support these in the classroom. (Sandra & Julie)*

Seeking further outside help to learn more about GIS led to Sandra and Julie employing a GIS specialist to come into school and map local data through GIS with their pupils:

*Finding data – having begun to get to grips with some of the basics of GIS software once we were able to identify opportunities for its use in our schemes of work. In particular we were keen to support some GCSE mapping. However getting the data (e.g. the census data) needed for this proved to be very difficult and is a current sticking point for us. A consultant from a company that was using GIS to produce maps for the Olympic bid was able to visit our school and work with a small group of gifted and talented pupils to produce maps from fieldwork data that they had collected. (Sandra & Julie)*

Sandra and Julie described how they used local data available online to map areas close to the school:

*We also developed a short series of lessons based around local flood risk maps available on the internet. These simple maps introduced the pupils to some of the basic skills of GIS. (Sandra & Julie)*

Sandra and Julie focused on making small, manageable steps which they perceived as leading towards higher quality development of their curriculum with GIS:

*It's important to develop links with those in the know; Wherever possible we have tried to work with those familiar with and skilled at using GIS. For example our visiting consultant was able to work with pupils and produce maps using ArcView very quickly and this helped them gain something tangible from it. We also worked with a teacher from another school who had successfully worked with GIS for a long period of time. He was able to help us plan our use of GIS and see how we could move forward. (Sandra & Julie)*

#### 4.8.3 Teaching outcomes

Whilst Sandra and Julie cited a number of successful curriculum developments with GIS in their department, one of the key outcomes for their teaching was an even greater awareness of the need for further specialist training:

*Introducing GIS to our geography curriculum has not been easy and in many ways we are still in the very, very early stages of doing this. Several key issues have presented themselves since we began work on the Spatially Speaking project. (Sandra & Julie)*

Sandra and Julie described the feeling of being overwhelmed by the complexity of ArcGIS:

*Understanding the terminology of GIS for example. Arcview and the 'wider world of GIS' has a great deal of subject specific terminology and getting to grips with this and beginning to engage with it was probably one of the biggest barriers for us. For example 'What is a shape file? A rastermap? Learning how to use the software ourselves – accessing the ArcView software is actually relatively simple once you get used to it, as it makes use of similar interfaces commonly used [in other software]. However the sheer scale and scope of the software is vast. (Sandra & Julie)*

Sandra and Julie also noted another challenge for relatively inexperienced users of GIS, including both teachers and pupils because, often a teacher's lack of confidence in using GIS could reduce their pupils' learning to a rather procedural level. Both felt that improving their conceptual understanding of GIS could only benefit the overall outcomes for geography in the lesson:

*How can we get pupils to understand the concepts behind GIS (when we are new to the field too) and encourage them to develop their own ideas for its use, rather than simply following a set of instructions on a sheet? (Sandra & Julie)*

#### 4.8.4 Learning outcomes

Sandra and Julie described how focusing on small groups of pupils allowed them to pilot learning with GIS:

*Start small. Select a target group to work with you to learn about GIS. Our main focus in the initial stages of our work with ArcGIS has been to work with gifted and talented pupils. These pupils were able to gain a great deal from the work and also helped us to learn more about the programme. (Sandra and Julie)*

Both Sandra and Julie acknowledged that their pupils took a great deal of satisfaction in learning how to use GIS:

*These pupils involved enjoyed using the software and were very pleased (and proud) of the maps that they were able to create. However it was frustrating for them at first as it took a*

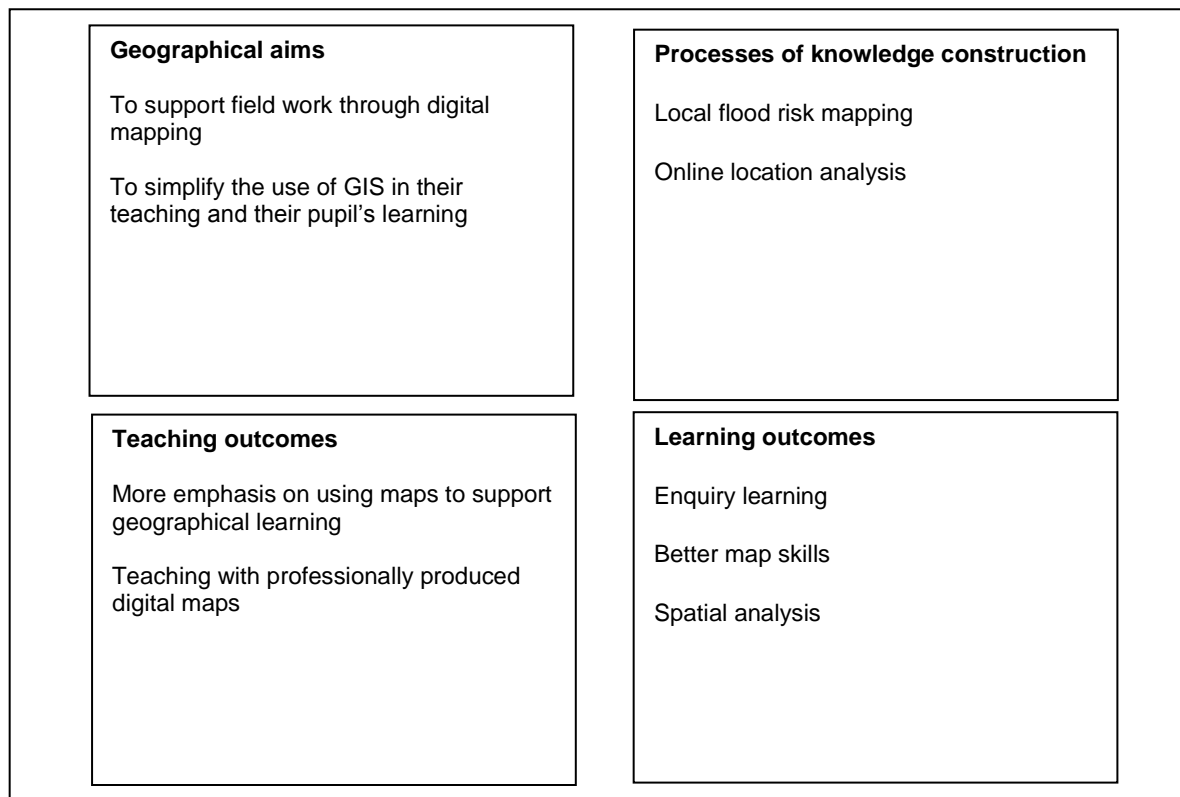


*long time to set up the maps and get to know GIS – what it was, what it could do.(Sandra and Julie)*

#### 4.8.5 Summary

Sandra and Julie described a number of key areas in their curriculum development with GIS. Their main aims for using GIS were to enable their gifted and talented pupils in particular to visualise spatial patterns and to map these through GIS. They indicated that using data collected and analysed through GIS promoted better geographical understanding amongst their pupils. Both described the challenges they had met by through using GIS. These included the need for on-going training for teachers if they were to move their pupils beyond instruction-led GIS in their geography.

**Figure 4.7** Outline of GIS practice – Sandra & Julie



#### 4.9 Results of analyses – John

John was a head of department at an independent school in Hertfordshire. He was involved in training teachers across the United Kingdom in the use of GIS and had written a textbook on the use of GIS in A Level Geography teaching. As a result, he was considered an 'expert user of GIS' for the purposes of this research.

##### 4.9.1 Geographical aims

John placed considerable emphasis on using GIS to frame his pupil's learning and to give them the skills to use GIS in analysis:

*Our aim is to help pupils to analyse geographical data more effectively. It is still developing as we integrate GIS into our learning programmes. But a range of areas in the curriculum – spatial patterns in migration, environmental quality surveys and use are now being taught through GIS in the school. (John)*

##### 4.9.2 Processes of knowledge construction

In terms of specific processes of GIS used in knowledge construction, John identified location analysis as major areas of geography curriculum development in his school:

*We have used GIS as a tool for example to locate a site for a local skate park. This kind of activity capitalises on their interests. Project work is enhanced with GIS. Presentation is a lot easier. Using spatially-referenced data equals proper geography, what's vital is that we don't get lost in the IT and forget about the geography. Pupils are given the opportunity to use spatially-referenced data about their local area. For me that equals 'proper geography. (John)*

John also discussed how his pupils used GIS in land use surveys of their local area. He discussed use of aerial photographs, maps and direct fieldwork experience to test a number of hypotheses based on urban land use theories.

#### 4.9.3 Teaching outcomes

John discussed the benefits of high quality spatial data to support geography teaching. He placed considerable emphasis on the need for teachers to model high-level GIS skills if they are to teach effectively with GIS. He also acknowledged a need for more critical use of GIS, something he also encouraged his pupils to develop. John discussed his training of teachers in his department and in other schools. He offered this advice for future training:

*We need teachers to start sharing with others in their local area. Between PGCE students and their mentors. The demand is out there – we need to create more opportunities for teachers. (John)*

#### 4.9.4 Learning outcomes

John emphasised the key advantage of developing spatial analysis in his pupil's learning through GIS. He cited both the improved quality of fieldwork and a range of work –related skills developed with GIS:

*What has become clear over the five years that we have been using GIS with the GCSE classes is that their fieldwork has been enhanced through using GIS. (John)*

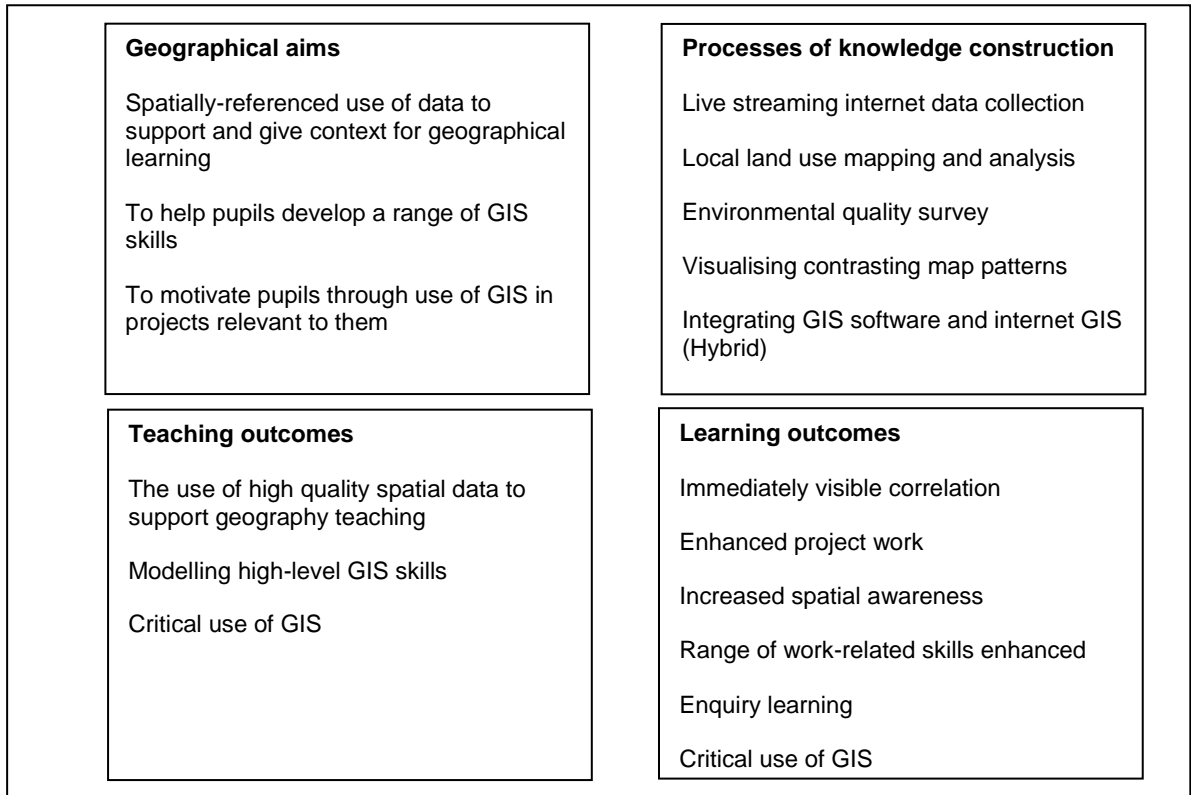
John described how he tailored the use of GIS to suit different ability groups:

*It's also good for differentiation between foundation and higher levels at GCSE. They get to use the GIS tools regardless of their ability and use 100% of their potential. (John)*

#### 4.9.5 Summary

John described a number of key areas in his curriculum development with GIS. His main aims for using GIS were to enable pupils to visualise spatial patterns and to map these skilfully through GIS. He used GIS as a motivational tool and was particularly keen for his pupils to use GIS to support their field work. He described the challenges met by using GIS and makes suggestions regarding improved training for teachers.

**Figure 4.8** Outline of GIS practice



#### 4.10 Stage summary of findings

All nine teachers identified their main aims for using GIS in school geography were to visualise (and particularly to map) spatial patterns and to link geo-referenced data. There was an element of inevitability to the way within which the more experienced GIS users: David, Mike and Simon and John, identified geographical aims which involved more complex use of the more advanced technical capacities of GIS. These included linking primary and secondary data in fieldwork, scientific measurement and display of a range of geography-related phenomena, for example, weather patterns and integrating desktop GIS data with internet GIS. All teachers also described the benefits of using GIS to support decision-making exercises and to develop their pupils' abilities to use GIS data to support more informed argument and geographical debate.

Most also saw the latter as motivational for pupils who could use GIS to study projects that were relevant to them and/or based on 'real-world data.' Of the four teachers with more GIS experience

(two of which were working in the same school it does need to be remembered), one specifically identified the importance he associated with GIS in providing geographical context for learning (John), Mike and John made a clear link between using GIS and being able to process and display large amounts of geography-related data quickly and effectively. Of the five less experienced GIS users, Jenny and Marco identified their aim for pupils to experience work-related skills in their geography lessons, whereas Sandra and Julie identified their aim to use simplified GIS procedures in their lessons.

In terms of processes of knowledge construction, all teachers emphasised mapping as their most used method, the more experienced GIS users had collected fieldwork data and measured geographical patterns with (often mobile) forms of GIS. All teachers had used a form of online GIS to carry out a form of site analysis, with this form of knowledge construction being most prevalent amongst the less experienced users of ArcGIS in the group. In the main, these teachers used free online viewers as substitutes for ArcGIS during the course of the Spatially Speaking project.

With regards to teaching outcomes, most teachers emphasised the effect that GIS had on moving them away from more didactic teaching approaches to more pupil-centred, facilitating roles. In terms of pupil learning teachers emphasised the ways in which pupils could correlate patterns through GIS, the importance of their producing and interpreting maps (often of a professional standard), an increase in spatial awareness and their development of better skills of enquiry.

## Chapter 5 Mapping the Land

### 5.1 Introduction

The main aim of this chapter is to examine the role of GIS in constructing relational place knowledge. The chapter contributes further to answering the first research question: *How does GIS influence teacher practice?* The chapter also addresses the second and third research questions:

- *How does GIS influence how teachers construct knowledge about place?*
- *How does GIS influence how pupils interpret place?*

The chapter shows the impact of GIS on geography teaching and learning in one class (Class X) observed during my six lesson observations at School A in the autumn and spring terms of 2007-8.

In the introduction to this thesis, I referred to Creswell's description of place which he described as being an inherently complex phenomenon but also as: '*a way of seeing, knowing and understanding the world.*' (Cresswell, 2004 p 11). I noted that there is a sense in which the thesis is an exploration of how GIS can be operationalized to synthesise relational knowledge about place through geography education. This chapter examines and analyses the teaching and learning that contributed to the construction of relational place knowledge in Class X.

The last chapter examined the influence of GIS on geography teachers' overall practice. In particular, it identified and explored the ways in which teachers use GIS to integrate and visualise geographical data. It focussed on the key process of synthesis of data in using GIS through key spatial concepts, tools of representation and processes of reasoning. Though the chapter did not examine the construction of place knowledge per se, it did support the theory that GIS encourages a particular kind of spatial thinking about geographical data which leads to knowledge and understanding based around site analysis, mapping geographical distributions and correlations and learning through one particular kind of 'GIS enquiry process (see Malone et al; 2005).

The logical step for this next stage of the research was to specifically explore the role of GIS in constructing knowledge about place, particularly relational constructions. The chapter focuses solely on place knowledge through a conventional GIS (in this case ArcGIS). The next chapter further explores that role but compares it with the use of Google Earth and a hybrid GIS (a combination of ArcGIS and Google Earth).

## 5.2 Background

The Geography department at School A had taken part in the Spatially Speaking project reported on in the last chapter. John, their head of department was a recognised 'expert' in the field of using conventional GIS in geography education and I wanted to explore his experiences and expertise further. During our time working together on the Spatially Speaking project, John had discussed a fieldwork project that his GCSE class had taken part in which used GIS to study their local town of Bishop's Stortford. The main aim of the fieldwork project was to answer the question: *What is the Urban Structure of Bishop's Stortford and does it fit the models of Burgess and Hoyt?* I carried out research at John's school because wanted to witness first-hand the ways in which he used GIS to support learning about place.

Class X consisted of twenty-two Year 11 pupils of mixed ability and gender. The class were working on a local fieldwork project mapping housing quality and land use. The data they collected was used in a critical analysis of the applicability of the Burgess and Hoyt urban land use models to their local town of Bishop's Stortford. Prior to my observations, pupils had been introduced to the concept of urban land use models and how these could be compared to settlement structures in the field. Pupils had also explored the concept of environmental surveying and had devised their own environmental quality scale. Their class teacher had also introduced them to the range of satellite, Ordnance Survey and census data held on the school's central GIS system. Prior to carrying out their fieldwork surveys, pupils used that data bank to preview their likely fieldwork route and to select points where they would collect their housing quality and land use data. During their field visit, pupils collected data on a range of environmental factors observed and measured at each site visited. Once pupils had visited their sites they moved onto the next stage which involved digitising site data. It was at this stage that I carried out the first lesson observation.

### 5.3 Data collection

During the course of six observations I collected data on a range of activities using ArcGIS in Class X .Figure 5.1 summarises the main features of each of the lessons.

**Figure 5.1** Overview of lessons

Observation	Focus	Data
1	Mapping fieldwork sites	Lesson observations document analyses (+ teacher interviews during visits)
2	Connecting fieldwork with census data	
3	Using maps and satellite images together	
4	Analysing changes in land use	
5	Using geographical evidence to support land use analysis	
6	Mapping land uses	

Section 3, Chapter 3 provided a detailed rationale and description of the methods of observation followed at School A. However, it is useful to re-iterate before describing the observations in full that I chose an open approach because I wanted to capture as much detail of the lessons witnessed as possible whilst avoiding pre-conceived categorisation. There can be a problem with such an open approach, as it can be too unfocussed, often leading to premature judgements being made. It can be argued that the best way to handle such an open approach is to describe ad verbatim as best they can what you can observe and leave interpretation until after the observation (Hopkins, 2004). It was this kind of open approach to observing and then interpreting that I chose to adopt. When I first visited School A, I used this more open style of direct observation but included a number of prompts and guidelines to semi-structure my observations. I based these around the processes of teaching and learning in each lesson, the nature of place knowledge being constructed and the ways in which



GIS was being used to relate knowledge. As a result, my lesson observation prompts included these questions:

- *How is the classroom teacher organising their teaching with GIS?*
  - *Which procedures are pupils using when working with GIS?*
  - *How is place knowledge constructed through GIS in this lesson?*
  - *To what extent is relational construction of knowledge about place evident in this lesson?*

In the first observation, I changed my observational focus approximately every five minutes in order to observe as many individuals and interactions as possible (Lankshear and Knobel, 2004). I wanted to 'get a feel for' what was going on in the classroom and describe in as much detail as possible the interactions between John and his pupils and the ways in which they were using GIS. Cole (2003) refined her selective observations to focus on fewer students and revealed a number of key themes which may very well have been missed in a whole class observation (Lankshear and Knobel, 2004). I adapted this approach, focussing in more on particular individuals where I felt I could glean richer data about the teaching and learning processes occurring and where John had recommended observing particular pupils. In her classroom research on early readers, As the 'Results of analysis' below shows, at this stage in the case study research, I had begun to follow up on my early 'hunches' during data collection, in my opinion, I was starting to 'get at the significance of certain events and practices' (Lankshear and Knobel, 2004, p 221). As Figure 5.1 also indicates, I also carried out interviews with John both before and after the observations and spoke informally with pupils during my lesson observations. Where relevant I have included excerpts of these conversations in the 'Results of Analysis' section.

#### 5.4 Procedures of analysis

The principles for analysis discussed in Chapter 4 were adapted for this stage of the empirical research. There, I opted to select significant and sometimes lengthy quotations from teachers because I wanted to preserve as fully as possible their experiences of and opinions on using GIS. In the data collection and analysis reported on in this chapter and the next I chose to examine patterns across the three elements of the data set. As Figure 5.2 illustrates, this initially involved open coding of the data collected during lesson observations, teacher interviews, conversations with pupils and

class document analysis. The data was then coded via the categories of: geographical aims, pedagogy, GIS processes and place constructs.

**Figure 5.2** Procedures of analysis

Stage	Aim	Procedure
1.Data Coding I	To identify themes emerging in the observation and document data	Open Coding
II	To subsume/amalgamate similar coded categories	Comparison coding of data against conceptual framework themes of :pedagogy and place constructs
2. Data Display	To summarise identified data themes	Summary made of data themes identified in each observation
3.Data Description	To describe teaching and learning processes about place through GIS	Written description of data themes of geographical aims, pedagogy , GIS processes and place constructs
3. Written Summary	To summarise the influence of conventional GIS on place knowledge construction	Written summary of findings
4. Conclusion	Dialectical theory building	Iteration between findings from stage 1and 2 and conceptual analysis (Chapter 2)

## 5.5 Results of analyses

This section presents observations from each of the six lessons. Some of the descriptions are accompanied by illustrations from the document data where appropriate (see Appendix *Mapping the Land*). A summary diagram of the findings of each is provided at the end of each section organised under the four main data themes already identified.

### 5.5.1 Mapping fieldwork sites

At the start of the first observation, pupils were soon busy entering their primary fieldwork data into ArcGIS. They had collected their data on paper maps out in the field and were painstakingly transferring this across to ArcGIS. As the lesson got fully under way most began following the step-by-step instructions provided on how to digitise the data. As I watched, most were zooming and panning across the image, shifting the display to see different views of Bishop's Stortford and to find the sites they had visited individually. Pupils were working on one of two routes around the town, one conducted in the morning and one in the afternoon. I watched a student pull up his route onto the screen and identify the points that he had visited on the Ordnance Survey map displayed. Another student identified the areas of the map divided into census areas and picked on the one which holds his first fieldwork visit site. He applied the fixed zoom function to keep the map steady and began to digitise his points. At the same time, John began to explain to the rest of the class how to import their own data into ArcGIS.

**Figure 5.3** Locating fieldwork sites in ArcGIS

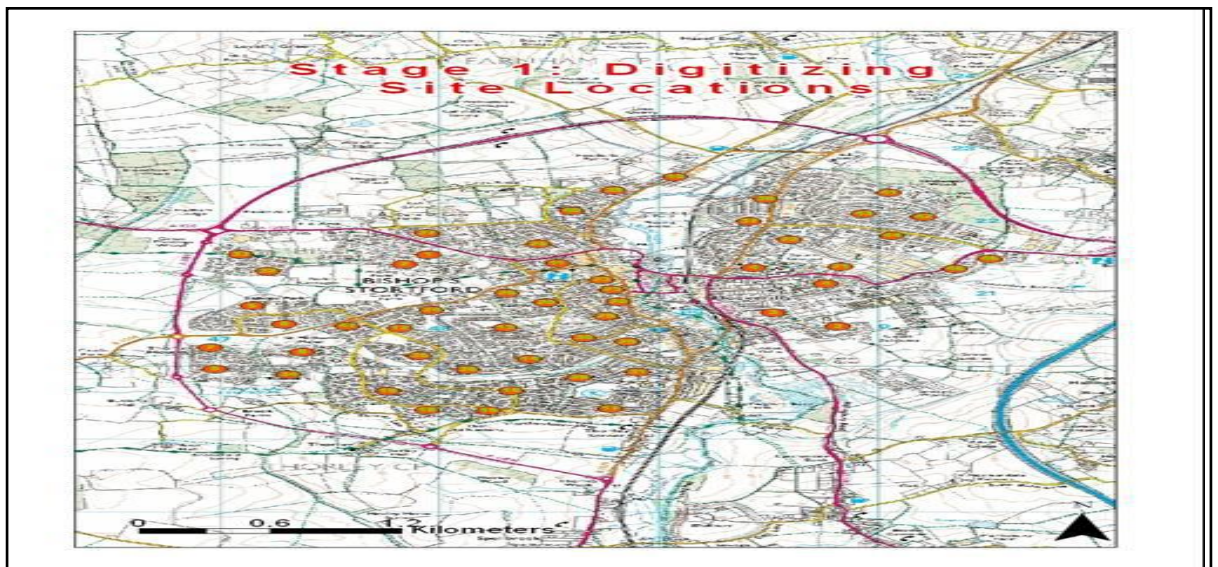
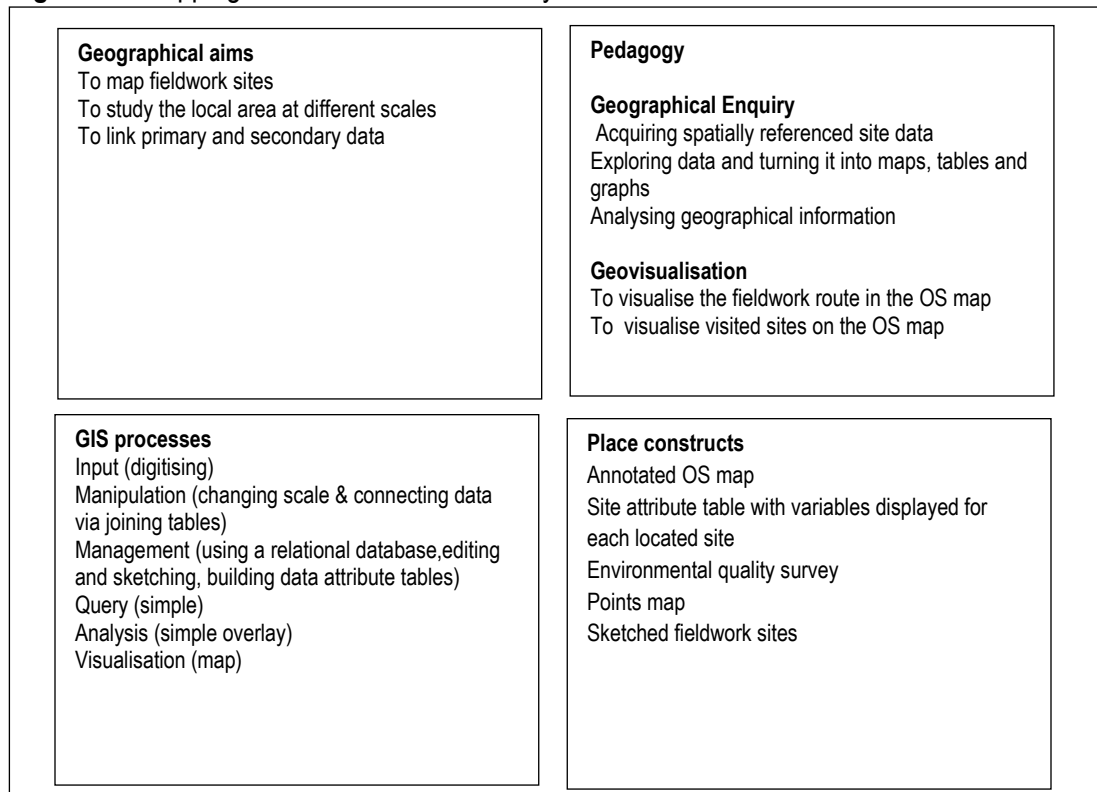


Figure 5.3 illustrates the base map that pupils in the class were working on. Some pupils had already entered their data into an Edexcel spreadsheet and some had already started transferring the information across to ArcGIS. John explained to the others that before they could map their data they would need to enter it into Excel in a format that ArcGIS would later recognise. I watched a number of pupils entering their sites as numbers and identifying which map polygon each site could be found in. John emphasised the need for pupils to be very careful in transcribing the data, explaining that ArcGIS would only recognise the rigorous format identified in the hand-out. Once pupils had entered this initial data they began to enter description variables for each site. These included information about house size, garden size, road access, number of windows, standard of maintenance, parking facilities and distance from the Central Business District. Each of the sites was then given an environmental quality grading as part of the overall assessment of housing quality. Pupils then totalled their scores and entered these into their spreadsheets.

John explained that pupils would need to save their spreadsheet into another format (dBASEIV) so that ArcGIS could read and import it. This was challenging for some pupils and several had to be helped through the fairly intricate procedures involved. Next pupils moved on to connecting their site data to their Ordnance Survey map of Bishop's Stortford. I watched as pupils created new shapefiles and added this data to their Bishop's Stortford map. Another pupil also turned the fieldwork route layer on and off to help them identify their individual site locations more easily. Having added their

fieldwork shape file to their project folders, most pupils moved on to marking their fieldwork sites. I observed pupils editing their maps to create a new feature: their fieldwork sites as points. Using the sketch tool they began to draw on their site locations. During this process, John advised them to open attribute tables and enter data on each of their sites. He explained that this would allow them to add their descriptions of each site as they went along. Pupils spent the next stage of the lesson carefully drawing on their field work sites with the ArcGIS sketch tool. As the end of the lesson approached, John displayed a finished map (completed by a pupil) which showed all of the sites he had collected and digitised and the data stored in the attached attributes table. John walked around the classroom helping individuals who were struggling with joining folders or opening applications. He continued to monitor progress and discuss links between the data collected and the land use patterns with individual pupils. Figure 5.4 summarises the main aspects of the work involved in mapping the fieldwork.

**Figure 5.4** Mapping fieldwork sites – Summary



### 5.5.2 Connecting fieldwork with census data

At the start of the second observation, pupils began to compare their own field data on housing quality and land use with the 2001 census data. John described the range of variables that pupils had investigated on their visits to their sites (including house size, garden size, environmental quality, distance from the main road, parking). He explained that the most important part of the lesson involved further analysis of the nature of the variables for each site and being able to identify the geographical reasons (either or both physical or human) for the variation in housing quality shown. Pupils were also told to study similarities and differences with the 2001 census data file. This proved to be a complex procedure for most pupils with several steps involved in processing the data. This began with pupils starting to join their attribute table data to their Ordnance Survey map.

Once the majority of pupils had completed joining the table to the map, John explained the next stage which was to symbolise their site data so that they could produce other maps for their project. The first map that pupils began to create was to show the urban structure of Bishop's Stortford. John explained that this would involve using graduated symbols to show variation in housing and environmental quality. I then observed pupils choosing different sized and coloured symbols for their maps. John explained that the purpose of choosing the type of symbol was to make their maps easier to read. Pupils chose symbols to represent high, medium and low quality housing. Figure 5.5 summarises the main ways in which John and his pupils connected fieldwork with the census data.

**Figure 5.5** Connecting fieldwork with census data - Summary

<p><b>Geographical aims</b> To map the variety of variables collected on each site To compare collected variable data with data from the 2001 census To make informed comparisons between the primary and secondary data</p>	<p><b>Pedagogy</b></p> <p><b>Geographical Enquiry</b>- Exploring data and turning it into maps, tables and graphs/Analysing geographical information</p> <p><b>Geovisualisation</b> To visualise the variety of physical and human characteristics of each site</p>
<p><b>GIS processes</b> Manipulation (of scale, symbolising maps) Management (using a relational database) Query (simple) Analysis (simple overlay) Visualisation (map)</p>	<p><b>Place constructs</b> OS map Urban structure map Site attribute table Satellite imagery Census attribute table</p>

### 5.5.3 Using maps with satellite images

The third observation lesson began with John explaining that this task involved the use of maps and aerial photographs to display the main features of the sites visited during fieldwork. The aim was to use the evidence provided to define areas as low, medium or high quality housing. John explained to the class that the more evidence they collected and documented in this way the more pupils would be able to write about in their project.

**Figure 5.6** Connecting map and satellite image data in ArcGIS

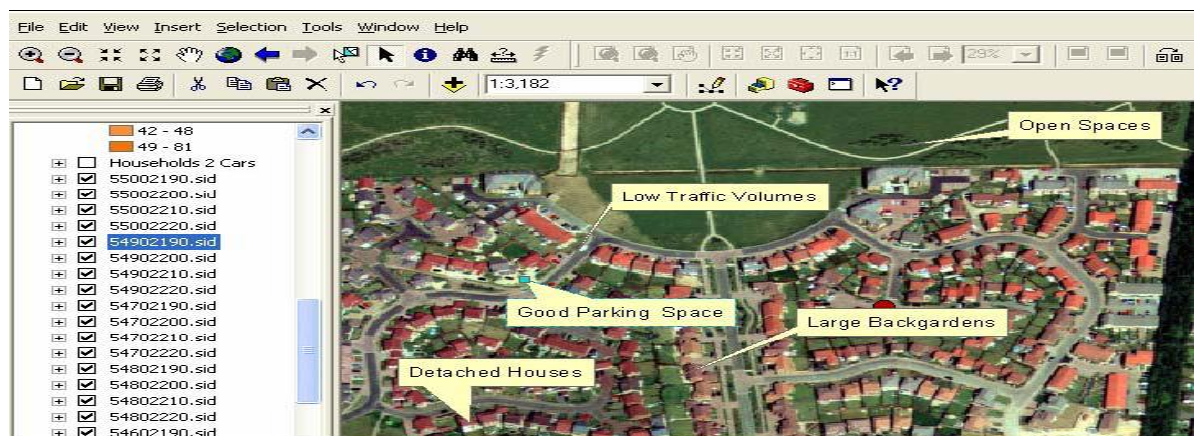


Figure 5.6 illustrates the way in which pupils annotated data from their maps onto the satellite imagery on housing. Pupils began by identifying features in the aerial photographs that they associated with a high quality residential zone e.g. more windows on a house, a larger back garden. They then labelled these features using the callout box in the drawing toolbar in ArcGIS. As the lesson progressed, most pupils moved on to using the aerial photographs to make the connections between human and physical features and designated areas of high, medium and low quality housing.

I observed one pupil as she studied an image of an industrial area. She zoomed in on some buildings near the river showing me the lack of residential buildings. She compared land prices, clicking on the associated attribute tables to show me how prices varied from place to place in the town. Focusing in on the higher land away from the river, she navigated back to the aerial photographs, telling me that according to the census data, the house I could see in the image with more windows, a larger garden

but near to the school was the more expensive. At the end of the lesson, John engaged the class in a discussion about the variation of physical and human features of their sites. As the lesson moved towards its close John reminded the class to finish labelling their annotated photographs and to give them a title, scale and north point. Figure 5.7 summarises the main ways in which John and his pupils used maps with satellite images in this lesson.

**Figure 5.7** Using maps with satellite images – Summary

<p><b>Geographical aims</b>          To explore and analyse land use change over time          To annotate and compare Ordnance Survey maps and satellite imagery          To provide evidence to back up geographical pattern identification          To describe areas of low and high quality housing</p>	<p><b>Pedagogy</b></p> <p><b>Geographical enquiry</b> – To explore data and turn it into maps, tables, graphs          To analyse geographical information</p> <p><b>Geovisualisation</b>          Identify physical and human geographical features          Visualise key geographical features/examine their key characteristics</p> <p>Make connections between visualised features</p> <p>Annotate maps and satellite imagery</p>
<p><b>GIS processes</b>          Manipulation of scale          Management (using a relational database)          Query (simple)          Analysis (simple overlay)          Visualisation (map)</p>	<p><b>Place constructs</b>          Annotated Satellite image          Annotated Map          Choropleth Map          Site attribute table</p>

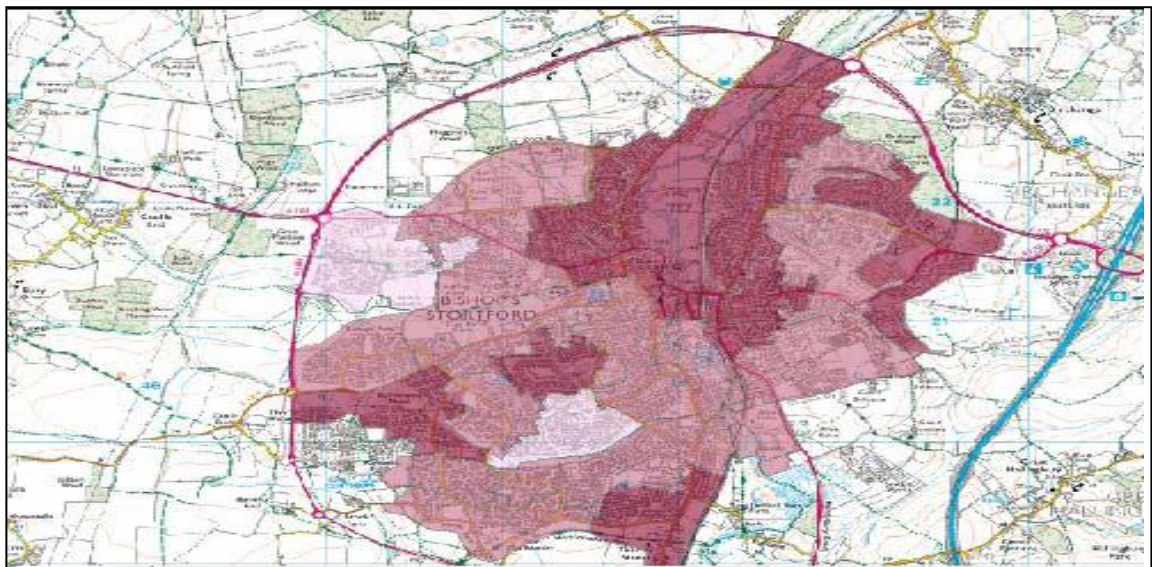
#### 5.5.4 Analysing land use changes

At the beginning of the fourth observation John explained that pupils would now move on to study changes in land use. Pupils began opening and studying the historical map of Bishop's Stortford. I observed pupils opening and displaying both the map layer containing their field data and the map layer containing the census data. Pupils used the join data procedure to join their site housing data to the map



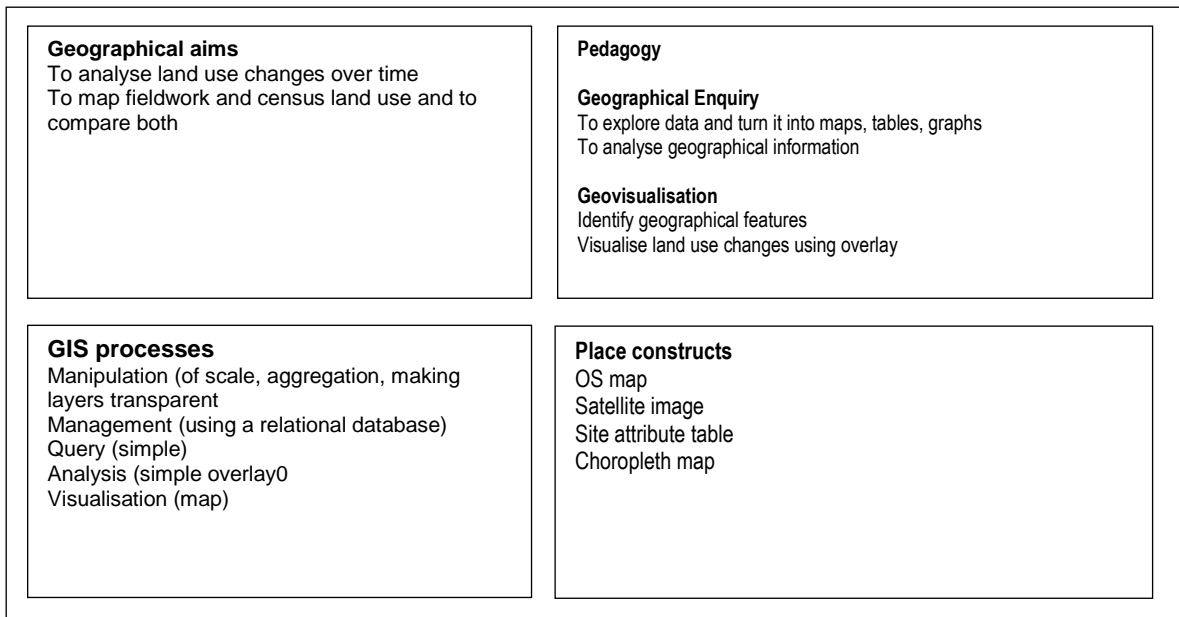
As John monitored progress he asked individuals about the significant similarities and differences between their data and the census data. One pupil remarked on the subjective nature of their environmental scoring survey and how this may have affected the difference in shading shown on the housing quality choropleth map. In the middle part of the lesson, pupils moved on to aggregating data which involved linking their fieldwork sites already drawn on their OS maps to the census data areas. John explained that data aggregation would involve displaying point data by area. He explained that pupils would then be able to have a clearer idea of the variation in housing quality across Bishop's Stortford.

**Figure 5.8** Adding census data layers to the ArcGIS Ordnance Survey map



Towards the end of the lesson some, (though not all pupils) moved on to shading their map to show a transparent layer which allowed them to view the site and census data together. John explained to the class that this process would allow some of the detail for one layer on the map to be visible through another. He demonstrated how this could be done by placing the census data over the Ordnance Survey map. Figure 5.9 summarises the main ways in which John and his class analysed land use changes in this lesson.

**Figure 5.9** Analysing land use changes – Summary



### 5.5.5 Using evidence to support analysis

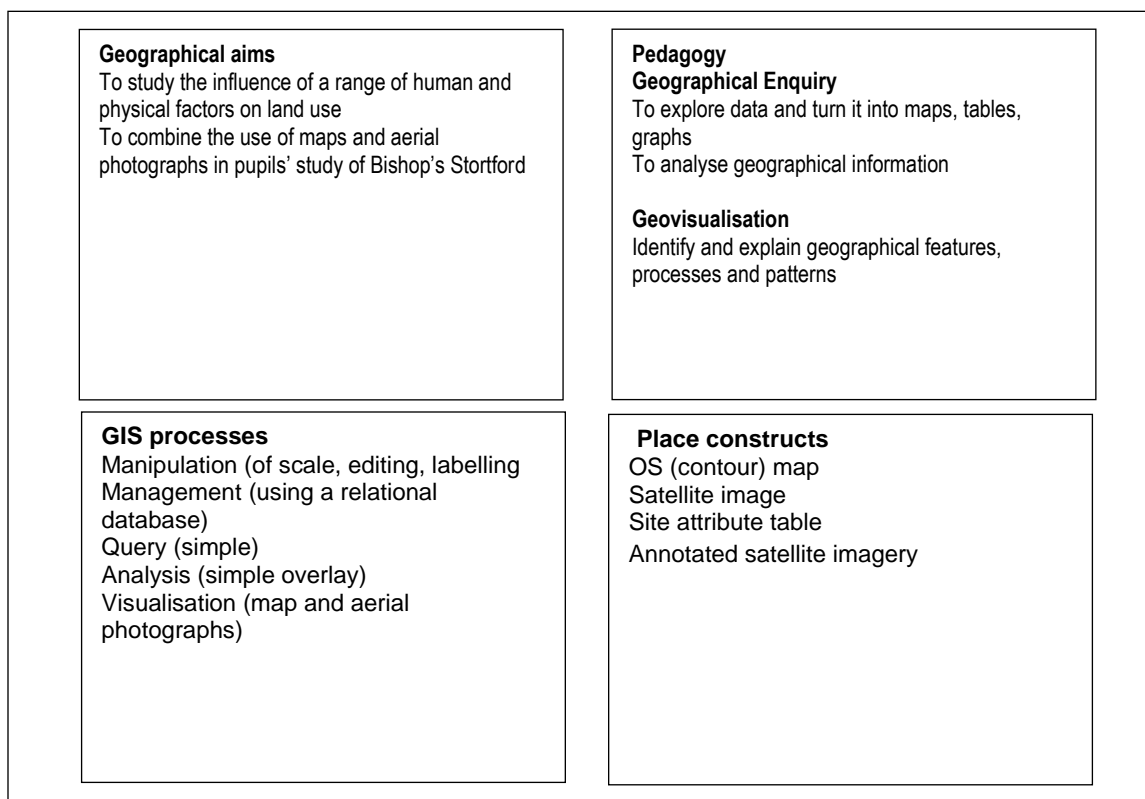
This lesson began with John demonstrating to the class the variety of physical and human features that could be identified on the Bishop’s Stortford OS map. He explained that the main aim of today’s lesson is to use GIS to study more closely the physical and human geography of each of their chosen field work sites and to use this evidence to support their analyses. The class began a discussion on the physical shape of Bishop’s Stortford and how the topography has led to the town developing along the valley of the River Stort. John asked pupils to follow the outline of the valley on their screens. He explained, using the main class board and zooming in on contour lines, how the valley changed shape downstream.

I observed several pupils as they symbolised their site data and began to categorise areas into high, medium and low quality housing. I observed other pupils turning on the aerial photography layers so that they could look at the features of their chosen sites more closely. Pupils moved

between the different sets of data, looking first at the Ordnance Survey map and then at the satellite image, identifying different sites and noting their relative human and physical characteristics.

One pupil used her digital Ordnance Survey map to look at how the physical geography had shaped the town. She zoomed in and out of the maps looking at contour shapes and the lines of the main valley in which the town sat. She looked closely at the sites close to the River Stort, panning the map, comparing the contour heights; identifying which buildings were located above the floodplain and those that were not. She showed me a list of variables (including the physical characteristics of the Stort Valley) that might have affected how land use patterns have developed. She also pointed out her chosen sites on the screen and a variety of attributes connected with them (land values, access to main roads school access amongst others). I watched as she started to annotate descriptions of her sites in textboxes at each of her chosen locations. Figure 5.10 summarises the main ways in which John and his class used evidence to support analysis in this lesson.

**Figure 5.10** Using evidence to support analysis – Summary



### 5.5.6 Land use mapping

At the start of the final observation John explained to the class that this final part of the project was to complete their land use mapping. He explained to pupils that this was a complex procedure and that for some, producing a final hand-drawn map from their fieldwork was also acceptable. It was clear from my observations that pupils were indeed at different stages of completing this task. I observed several pupils opening their Bishop's Stortford file and choosing a land use layer to draw. One pupil selected an industrial land use area shapefile. I watched as he started to edit his data and move it from his database and onto his Ordnance Survey map. He began to use the pencil tool to trace his chosen industrial area on the map. John was at this time explaining this procedure, using another pupil's work. The pupil (and the class as a whole) listened carefully as John explained further how this drawing of a map polygon would allow those completing digital maps to locate their areas. The middle part of the lesson involved the more competent pupils editing layers on their map and adding new features. Most of these pupils appeared very adept in using the editing tools (e.g. the pencil to trace outlines on the map). During the remainder of the lesson, I observed pupils other pupils tracing the outlines of the other land use areas onto their OS maps of Bishop's Stortford by hand. Some pupils in the class also began to write summaries of their conclusions on the extent to which Bishop's Stortford resembles the two land use models that they had previously studied (Burgess and Hoyt). Figure 5.11 summarises the main ways in which John and his pupils mapped land use in this lesson.

**Figure 5.11** Land use mapping – Summary

<p><b>Geographical aims</b> To map all land uses in Bishop's Stortford To test land use model hypothesis To reach initial conclusions based on evidence</p>	<p><b>Pedagogy</b></p> <p><b>Geographical Enquiry</b> Exploring data and turn it into maps, tables, graphs Analysing geographical information</p> <p><b>Geovisualisation</b> Identify and explain geographical features, processes and patterns</p>
<p><b>GIS processes</b> Manipulation (scales, polygonising, editing) Management (using a relational database) Query (simple) Analysis (simple overlay) Visualisation (via map and aerial photographs)</p>	<p><b>Place constructs</b> Land use map Ordnance survey map Site attribute table</p>

## 5.6 Stage summary of findings

In his interviews, John identified four key geographical aims for using GIS in his lessons. These were to give geographical context to his pupils' learning, to use spatially-referenced data, to help his pupils develop a range of GIS-related skills and to motivate them through geographical projects that were relevant to them. With more specific reference to the *Mapping the Land* lessons, John identified the key geographical aims for using GIS as being to map land use sites, to combine and compare primary and secondary data from pupil fieldwork and the Census and to produce a high quality land use map of Bishop's Stortford.

With regards to pedagogy, the two main approaches most evident in the lessons observed were geographical enquiry and geovisualisation. Pupils followed a distinct set of enquiry procedures whereby they acquired their data, turned it into maps, tables and graphs, described and explained land use patterns and mapped and reported on their findings (see Appendix 3). John used a scientific approach to carrying out geographical enquiry through GIS, capitalising on its suitability for rigorous hypothesis testing in the land use exercises that he designed for his pupils (see Appendix A3). With specific reference to GIS processes, pupils carried out a wide range of procedures associated with input, manipulation, management, query, analysis and visualisation. For example, in Lesson 1, pupils digitised fieldwork site data. Throughout the six lessons pupils manipulated their maps and satellite imagery at different scales. In each lesson pupils managed a wide range of organisational database-related tasks. Pupils carried out a number of simple GIS queries, for example where they were engaged in identifying and then joining housing data to site data. With regards to spatial analysis pupils buffered data to determine distances for example between residential houses and the nearest access road. Pupils integrated a range of data layers through the process of overlay.

Place constructs produced during this stage of the research comprised of Ordnance Survey maps, choropleth maps, and land use maps. Satellite images and site attribute tables. In their interviews and written work, pupils described and explained specific land use sites and discussed the impact of a variety of human and physical factors on sites, environmental quality, house prices and land use type.

## Chapter 6 Constructing the tsunami

### 6.1 Introduction and background

This chapter has three main aims. The first is to examine further the role of a conventional GIS (ArcGIS) in constructing relational place knowledge. The second is to examine the role of a virtual globe (Google Earth) in constructing relational place knowledge. The third is to examine the role of a hybrid GIS (which combines elements of conventional GIS and a virtual globe) in constructing relational place knowledge. With regards to the key research questions, the chapter contributes to answering the first, namely: *How does GIS influence teacher practice?* As with the previous chapter it also very specifically addresses the other two research questions:

- *How does GIS influence how teachers construct knowledge about place?*
- *How does GIS influence how pupils interpret place?*

The first part of the chapter describes the research setting. The second provides an account of how I went about collecting and analysing the data. The third part reports on the results of analyses. The final part summarises and discusses the findings with regards to the four main analytical themes, namely, geographical aims, pedagogy, GIS processes and place constructs.

The school where I carried out the research (School B) is a large mixed, denominational school in Brent in north London. Its 2100 pupils come mainly from north and west London and the surrounding Home Counties. In the same year that I visited, (2008-9), Ofsted carried out an inspection. In the opening statement of their report they wrote:

School B is extremely popular. The proportion of students who are eligible for school meals is below the national average. The proportion of students, who have learning difficulties and/or disabilities, including those with statements of special educational needs, is below national average. The school has specialist school status in humanities and a second specialism for raising standards.

(Ofsted, 2009)

The Ofsted description is a useful snapshot of the environment at School B. Though, it is important to note that though proud of its 'comprehensive system', the school's immediate area generally serves a broader socio-economic demographic. School B pupils are mainly from middle-upper income backgrounds and with the overall number with SEN fairly low.

I left the school seven years before I carried out this research and its essential characteristics had not changed. As a former member of the school's teaching staff I was in the fortunate position of being able to take advantage of both my recent 'insider' knowledge and my 'outsider' role as researcher. At the same time I was also cautious about what this combined role may entail with regards to maintaining the validity of my research findings. My concerns were based on my wishing to avoid misrepresentation through what could be construed as a biased personal perspective. Instead, I wanted to provide as objective an account of the research findings as possible. Lankshear and Knobel (2004) make a similar point about seeking 'researcher objectivity' when they argue:

Objectivity has to do with suspending values and assumptions about possible causes and outcomes, and eliminating 'passions' (feelings, wishes, personal investment and the like) that might render research findings invalid.(Lankshear and Knobel, 2004 p 65)

Whereas I had acted as an observer and interviewer in the earlier stages of the research reported on in Chapters 4 and 5, this time I was assuming the role of 'teacher researcher', putting myself closer to the centre of the teaching and learning processes that I wanted to investigate but also in a position of potential conflict as I pursued both of these endeavours. It is important to re-iterate here why I did this. Firstly, I had already gained valuable insights into teacher practice with GIS in the Spatially Speaking phase of the research. In Mapping the Land I had witnessed an 'expert' teaching his class about place through ArcGIS and interviewed his pupils about their learning experiences. In this phase I wanted to develop my understanding of the role of GIS in teaching and learning about place further by experiencing the teacher role and reflecting on it. Kemmis and McTaggart (1981) wrote about this kind of approach with regards to focusing on what is happening in a particular social situation (in my case the geography classroom) and what is problematic about it? Their argument is built around articulating clearly what is happening in working out ways to improve upon it. They argue:

You do not have to begin with a 'problem'. All you need is a general idea that something might be improved. Your general idea may stem from a promising new idea or the recognition that existing practice falls short of aspiration. (Kemmis and McTaggart, 1981, p 18)

Kemmis and McTaggart also suggest that this approach is emancipatory, and stems from a desire to improve professional practice which I can concur with in this research. When I carried out the research in 2008-9, the school was still thriving and over-subscribed. As Ofsted also noted, pupils were extremely easy to work with and were very used to 'outsiders' coming to work with them:

Students are extremely polite and considerate, and most speak articulately, and with confidence, to adults. Their spiritual, moral, social and cultural development is outstanding. Students' ability to work independently and together, along with their positive attitudes to work and their outstanding attainment, make an outstanding contribution to their being very well prepared for their future economic well-being.(Ofsted, 2009)

With regards to teaching at the school, standards were also generally considered to be very high. Ofsted described teaching as 'outstanding' going on to describe the major characteristics that they witnessed:

Teachers' subject knowledge is excellent and lessons are very well planned, containing a full range of activities to engage and interest students. New concepts are explained clearly, so that students know what is expected of them and, as a result, they tackle their work with confidence. Relationships between students and their teachers are exceptional. Students are given every opportunity to work independently and in groups, which they do extremely well. The pace of lessons is brisk and students are very well involved by the teachers' use of challenging questions, which require students to demonstrate high levels of understanding. (Ofsted, 2009)

The physical environment of the school was also significant. A new campus with ICT facilities placed very much at the heart of teaching made researching through GIS much simpler than it could have been in less-well accommodated facilities.



## 6.2 Procedures of data collection and analysis

During my period of preparation for the research I visited the school on four occasions to discuss the programme that I would follow with the head teacher, to seek permission for pupil involvement, to set up the technical requirements needed and to discuss classes that could be involved as research participants. I met with both the geography and ICT department and trialled some of the activities in a pilot study during the course of a week just prior to the main research.

I chose to teach about the 2004 South Asia tsunami and to use both a 'conventional GIS' in the form of ArcGIS and a 'virtual globe' in the form of Google Earth. I chose the topic partly because I wanted to engage pupils with as wide a range of GIS data accessible to schools at the time as I could, (the tsunami was well-resourced in this respect) and also because I had already carried out some work in my own teaching with GIS data available on the tsunami. The starting point for the series of lessons was the preparation of the GIS for use in the classroom with pupils. I prepared these using a range of data (from Dascombe, 2005) in an adapted version of ESRI ArcGIS 9 and from a range of web-based sources in Google Earth (see individual references in text to follow).

I designed the lessons to take pupils through a range of steps in using a 'conventional GIS' (ArcGIS in this case) and a 'virtual globe' (Google Earth in this case) and a 'hybrid' (lessons where both ArcGIS and Google Earth were used together) to study place. Specifically, the lessons involved their using the GIS to collect and analyse data about tectonic causes of the tsunami and its socio-economic and environmental effects. They used data about the region of South Asia as a whole and, at a more local level, about effects on villages near the main earthquake epicentre.

Class Y were chosen to participate in the research for a number of reasons. First, although teaching one class in a case study such as this could not be described as being truly representative of all classes within a school or indeed the wider secondary school population, I did intend to teach a group with as broad ability range and equal gender representation as possible. Class Y consisted of 22 pupils of mixed gender and abilities. Second, as their year group were taught in a carousel system, they were one of the few Year 9 groups who had recently completed work on natural hazards and, I assumed, this would help in contextualising

our work together. Third, they were about to begin a new twelve week unit of work in ICT which would allow me a lengthy enough period of time to introduce them to GIS, to teach the series of lessons planned and to carry out group interviews at the end of that period of time. During the research, I taught ten 1 hour lessons to Class Y, carried out 8 group interviews and collected a range of classroom documentary evidence including pupil work.

In this case study, I was a participant observer, teaching the lessons and also recording my observations. This was a complex procedure and it is important to clarify the main features of the method by which I produced the lesson descriptions. The writing involved compiling memos which closely resembled what Bogdan and Biklen (2005) define as descriptive and interpretative sequences. Put simply, my journal entries contained descriptions of activities, oneoff events and significant processes that I witnessed in the classroom. Memos also included my interpretations of the latter, ranging from identifying these as possibly significant in developing theory to much more tentative reflections and speculations. These descriptions were partly produced as shorthand during the lessons themselves and then written up as soon as possible after each lesson and annotated with memos once I had reflected on each of them more carefully. Alongside the descriptions of each lesson I also carried out an initial analysis with regards to the four key elements of geographical aims, pedagogy, GIS processes and place constructs. The lesson descriptions were used alongside the analysis of pupil interviews and document analyses to inform the summary and discussion of findings. Figure 6.1 provides an overview of the ten lessons taught at School B.

**Figure 6.1** Overview of lessons

Observation	Focus	Data collection
1	An introduction to ArcGIS	Journal entries, document analysis, pupil interviews.
2	Earthquakes and tsunami locations (ArcGIS)	
3	Tsunami impacts at a local scale (ArcGIS)	
4	Mapping earthquake variations(ArcGIS)	
5	Applying seismic gap theory (ArcGIS)	
6	Introduction to Google Earth	
7	Earthquake activity and tsunami impacts (Google Earth)	
8	Earthquake and tsunami impacts (hybrid GIS)	
9	Local & regional tsunami impacts (hybrid)	
10	After the tsunami (hybrid)	

My aims for coding and categorising remained the same as in the research reported on in the last chapter, I wanted to explore in this data:

- Geographical aims
- Pedagogy
- GIS processes
- Place constructs

The principles for analysis were the same as those applied in ‘Mapping the Land’ in that it seemed again appropriate to look for patterns across the data sets. Figure 6.2 sets out the main characteristics of the procedures of analysis followed. As Figure 6.2 illustrates, I coded across the three elements of the data.

**Figure 6.2** Procedures of analysis

Stage	Aim	Procedure
1.Data Coding I	To identify themes emerging in the observation and document data	Open coding
II	To subsume similar coded categories	Comparison coding of data against conceptual framework themes of :pedagogy and place constructs
3.Data Description	To describe teaching and learning processes about place through conventional GIS , Google Earth and Hybrid GIS	Written description lessons and identification (via summaries)of key elements of the data collected with regards to the key themes of:- Geographical aims, pedagogy , GIS processes and place constructs
3. Discussion of findings	To discuss key themes in relation to the research questions	Written discussion theme-by-theme
4. Conclusion	Dialectical theory building	Iteration between findings from stages 1,2 and 3 of the empirical research and the conceptual analysis (Chapter 2)

### 6.3 Results of analysis - ArcGIS

This section presents participant observations from each of the ten lessons .A summary diagram organised under the four themes of geographical aims, pedagogy, GIS processes and place constructs is provided at the end of each section.

### 6.3.1 Introduction to ArcGIS

The main aim of this first lesson was for pupils to gain a basic understanding of how ArcGIS organises and displays geographical information, to be able to view places at different scales and to identify key geographical features associated with the 2004 South Asia tsunami. The first part of the lesson was given over to explaining basic procedures of opening ArcGIS and describing our main focus on the 2004 Asian tsunami. Using the class board, I modelled the basics of using layers of information attached to a map, ways to use the zoom function and how to identify geographical features. Pupils worked through the introductory exercise on opening and using thematic layers, obtaining information from an attribute table and exploring map data (Appendix – Constructing the tsunami). Pupils acquired a number of key geographical resources to study key locations in this opening lesson, including the 'extent of the tsunami map', earthquake distribution maps and an earthquakes aftershocks attribute table.

Pupils explored the locations of the main countries affected by the tsunami, the positions of earthquake epicentres and the differing time periods of aftershocks. Pupils viewed areas affected by the tsunami and earthquakes at a regional and a local scale on the 'extent of tsunami map' and on the three earthquake epicentre distribution maps. They used the relational database to overlay themes and to begin to compare data sets.

As I monitored their progress, several asked for help with basic manipulation tasks – zooming in and out on the map (I directed those who were unaware of it to the *fixed zoom* function); others found it difficult to move easily between the map and the attribute data. By the end of the lesson, most were more confident and I concluded this first task with a class recapping exercise on how to successfully use a map and an attribute table together in ArcGIS.

**Figure 6.3** Screenshot of tsunami map

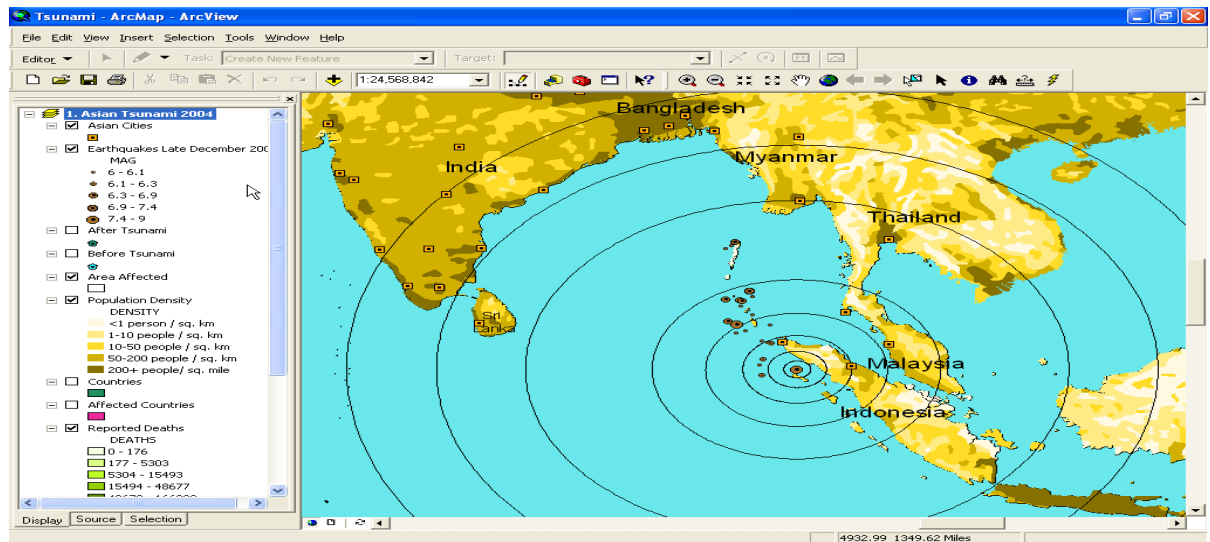


Figure 6.3 shows what could be best described as the ‘home screen’ for ‘Tsunami.’ This is the view that students would first see on entry to their lessons – displayed both on the main interactive whiteboard and on their individual work stations during the research. The view is typical of ArcGIS – the main map view screen in the centre; the table of contents (including attribute data) displayed on the left and the tool box) placed across the top of the screen.

**Figure 6.4** Introduction to ArcGIS – Summary

<p><b>Geographical aims</b></p> <ul style="list-style-type: none"> <li>To learn how GIS stores and displays geographical information</li> <li>To identify key geographical features associated with the tsunami</li> <li>To identify main countries affected by the tsunami/frame context</li> <li>To view areas affected by the tsunami at different scales</li> </ul>	<p><b>Pedagogy</b></p> <p><b>Geographical Enquiry</b> Acquire &amp; explore geographical data/Ask geographical questions</p> <p><b>Geovisualisation</b> Visualise key geographical features/examine their key characteristics Make connections between visualised features</p>
<p><b>GIS processes</b></p> <ul style="list-style-type: none"> <li>Simple manipulation</li> <li>Basic management (using the relational database)</li> <li>Preliminary analysis (via simple overlay)</li> <li>Initial visualisation (via maps)</li> </ul>	<p><b>Place constructs</b></p> <ul style="list-style-type: none"> <li>Extent of the tsunami map</li> <li>Earthquake epicentre distribution maps</li> <li>Earthquakes aftershock attribute table</li> </ul>

### 6.3.2 Locating earthquakes and tsunami

The main aim of this second lesson was for pupils to accurately locate earthquake distributions, to identify plate boundaries and to measure the extent of the tsunami. The first part of the lesson was given over to recapping on basic procedures already covered with pupils, namely how to use layers in ArcGIS, using the zoom function and identifying geographical features. Using the class board, I modelled the basics of identifying and selecting earthquake epicentres on the map and measuring a distance from an epicentre to a tsunami impact location. Pupils worked through an exercise on identifying key features of earthquake activity and the extent that tsunami travelled. They measured distances travelled by the tsunami. Pupils acquired and used a number of key geographical resources including the 'extent of the tsunami map', earthquake distribution maps and an earthquakes aftershocks attribute table. They made a number of simple but significant queries to identify plates, plate boundaries and the relationship between earthquake epicentres and tsunami distances and directions travelled. Pupils viewed areas affected by the tsunami and earthquakes at a regional scale on the 'extent of tsunami map' and on the three earthquake epicentre distribution maps. They used the relational database to overlay themes and compare data sets.

**Figure 6.5** Locating and exploring earthquakes and tsunami – Summary

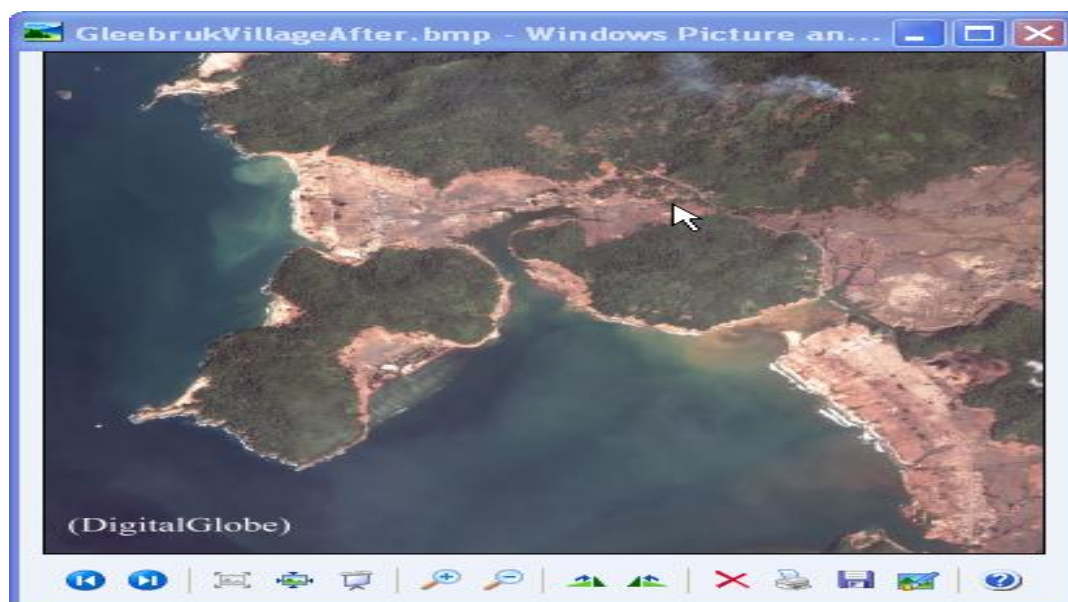
<p><b>Geographical aims</b></p> <ul style="list-style-type: none"><li>To introduce earthquake distribution, tsunami distances travelled and areas affected</li><li>To identify major tectonic boundaries in the area</li><li>To name places affected by the tsunami</li><li>To measure distances travelled by tsunami waves</li><li>To relate location and date of earthquakes and tsunami to areas affected</li></ul>	<p><b>Pedagogy</b></p> <p><b>Geographical Enquiry</b> Ask geographical questions/Acquire spatially referenced data/Explore geographical data</p> <p><b>Geovisualisation</b> Visualise key geographical features/examine their key characteristics Make connections between visualised features</p>
<p><b>GIS processes</b></p> <ul style="list-style-type: none"><li>Manipulation</li><li>Basic management (using a relational database)</li><li>Query (simple)</li><li>Analysis (via simple overlay)</li><li>Visualisation (map)</li></ul>	<p><b>Place constructs</b></p> <ul style="list-style-type: none"><li>Tsunami map</li><li>Epicentre distribution maps</li><li>Attribute table of earthquakes &amp; aftershocks</li></ul>

### 6.3.3 Tsunami impacts at a local scale

The main aim of this third lesson was for pupils to study the impacts of the tsunami at a local scale. The first part of the lesson was given over to recapping on basic procedures using layers, the zoom function, identifying geographical features and displaying data. Using the class board, I modelled the basics of adding theme layers, hotlinking images and sorting data. Pupils then located Banda Aceh and the two villages of Meulaboh and Gleebruk. Pupils worked through an exercise on the Banda Aceh, Indonesia region which involved them identifying the impacts of the tsunami on the area of Banda Aceh itself and two nearby coastal villages – Meulaboh and Gleebruk (appendix – Constructing the tsunami). Pupils acquired a number of key geographical resources including ‘before’ and ‘after’ photographs via the hotlinking tool and satellite images of Banda Aceh, Gleebruk and Meulaboh and ‘fixed zoom’ map images of each of the three study areas.

Once most pupils were established in the task I was able to circulate and observe their progress more closely. In my journal I noted the significance of a number of ways in which pupils were working. First, they used the fixed zoom feature to concentrate their view first on Banda Aceh, the two coastal towns, the road infrastructure and the earthquake epicentre distribution maps. This allowed them to work at a particular scale. Figure 6.6 illustrates an example where pupils explored a satellite image of Gleebruk village after the tsunami.

**Figure 6.6** Gleebrukvillage after the tsunami





Throughout this lesson, there were a number of technical procedures that several pupils found quite challenging and a small minority required quite lengthy one-to-one help despite the quite prescriptive instructions provided (Appendix – Constructing the tsunami).

Some pupils began working in pairs as ‘World Health Organisation emergency response co-ordinators’. They asked a number of simple spatial queries to identify impacts at each location (see Appendix A3 – Constructing the tsunami). They used the different thematic layers in ArcGIS to examine environmental impacts and damage to infrastructure. They identified impacts on the local population.

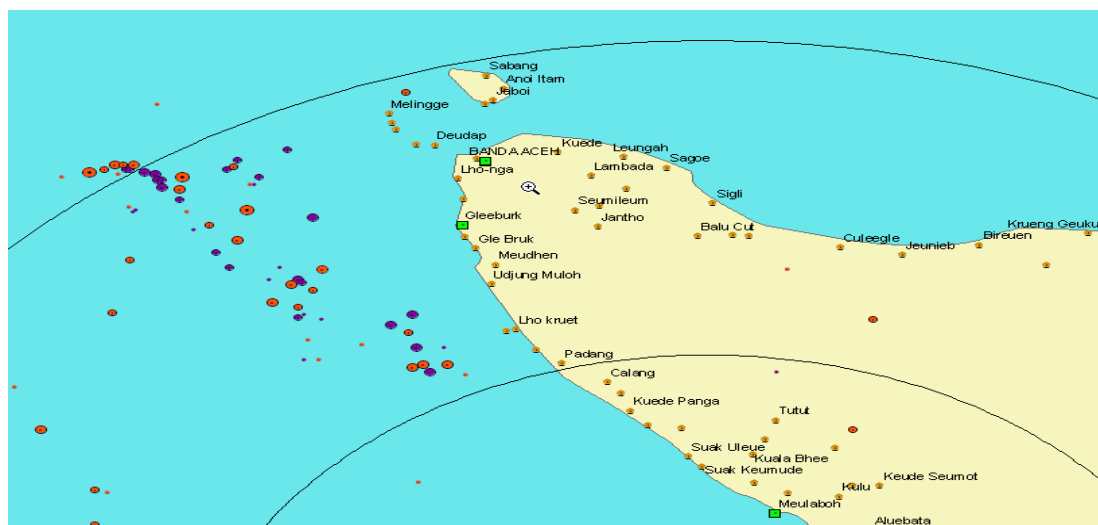
**Figure 6.7** Tsunami impacts at a local scale - Summary

<p><b>Geographical aims</b>          To study impacts of the tsunami at a local scale          To rank cities according to tsunami effects          To explain why some cities were more affected by the tsunami than others</p>	<p><b>Pedagogy</b></p> <p>Geographical Enquiry- Acquire geographical information/Exploring data -maps, tables and graphs /Asking geographical questions/Acting on geographical knowledge</p> <p>Geovisualisation</p> <p>Visualise key geographical features/examine their key characteristics/Make connections between visualised features</p>
<p><b>GIS processes</b>          Manipulation          Simple management (of a relational database)          Query (simple)          Analysis (simple overlay)          Visualisation (map)</p>	<p><b>Place constructs</b>          Tsunami ArcMap at regional and local scales          Before and After Gleebruk Village, Banda Aceh and Meulaboh photographs and satellite images          Attribute Tables of Population Densities and Countries with Deaths          World Health Organisation Situation Report 21 18<sup>th</sup> January 2005          Countries with Deaths Pie Charts (including deaths, injuries, missing)          Areas affected map annotated with pie charts showing deaths, injuries and missing</p>

### 6.3.4 Mapping and analysing earthquake distribution

The main aim of this fourth lesson was for pupils to map and analyse earthquake variations around the Banda Aceh area. The first part of the lesson was given over to recapping on basic procedures using layers, the zoom function, identifying geographical features and displaying data. I explained to the class that our main aim for the meson was to map earthquakes in the Banda Aceh area. Using the class board, I modelled the basics of adding theme layers, how to adapt map symbols if required and how to sort data. Once we had discussed basic data manipulation issues (mainly concerned with pupils finding moving files across into ArcGIS challenging), pupils began by working through a mapping exercise on the three locations in the Banda Aceh region studied in the previous lesson (Appendix – Constructing the tsunami). Figure 6.8 shows one of the maps used by pupils to study earthquake activity near to coastal villages in the Aceh area.

**Figure 6.8** Distribution of earthquakes at a local/regional scale



Pupils began the lesson by adding themes to their maps. Once most pupils were confident in the process and were able to begin the task on their own, I was able to begin observing the ways in which they worked whilst mapping the earthquake distributions. Once pupils had mastered how the symbology functions, most moved on to examining variations in earthquake activity in terms of time periods. I observed pupils sorting data in ArcGIS to identify the largest earthquake magnitudes and where and when these occurred. The remaining stage of the lesson was given over to pupils

completing the ranking exercises and identifying when and where the largest quakes occurred. Pupils acquired a number of significant geographical resources in this lesson, including the earthquake epicentre maps (over three time periods) and the ranked earthquake attribute tables.

**Figure 6.9** Mapping and analysing earthquake distributions – a summary

<p><b>Geographical aims</b>          To map variable earthquake distributions          To analyse earthquake patterns          To identify spatial and temporal variations in earthquake activity</p>	<p><b>Pedagogy</b>          Geographical Enquiry – To explore data and turn it into maps, tables, graphs          - To analyse geographical information</p> <p><b>Geovisualisation</b>          Visualise key geographical features/examine their key characteristics/Make connections between visualised features</p>
<p><b>GIS processes</b>          Manipulation (joining data)          Management          Query (simple)          Analysis (simple overlay)          Visualisation (map)</p>	<p><b>Place constructs</b>          Tsunami ArcMap at regional and local scales          Earthquake epicentre maps for three time periods          Earthquake attribute tables          Ranked magnitude tables</p>

### 6.3.5 Applying seismic gap theory

At the start of the lesson I explained to pupils that they were going to use ArcGIS to plot and predict future earthquake activity according to seismic gap theory. I explained that 'seismic' means an earthquake-prone area and that areas that have had less sustained or most recent earthquakes are usually less likely to suffer from them in the near future. Because ArcGIS is able to manipulate and display large amounts of data quickly, pupils are quickly able to display different earthquake scenarios on their map screens. Several pupils were quick to connect the pattern of lack of sustained recent activity with likely seismic gaps.

This lesson proved quite challenging for some pupils particularly with regards to manipulating data and joining tables. For some pupils, I provided joined tables of data so that they could see the

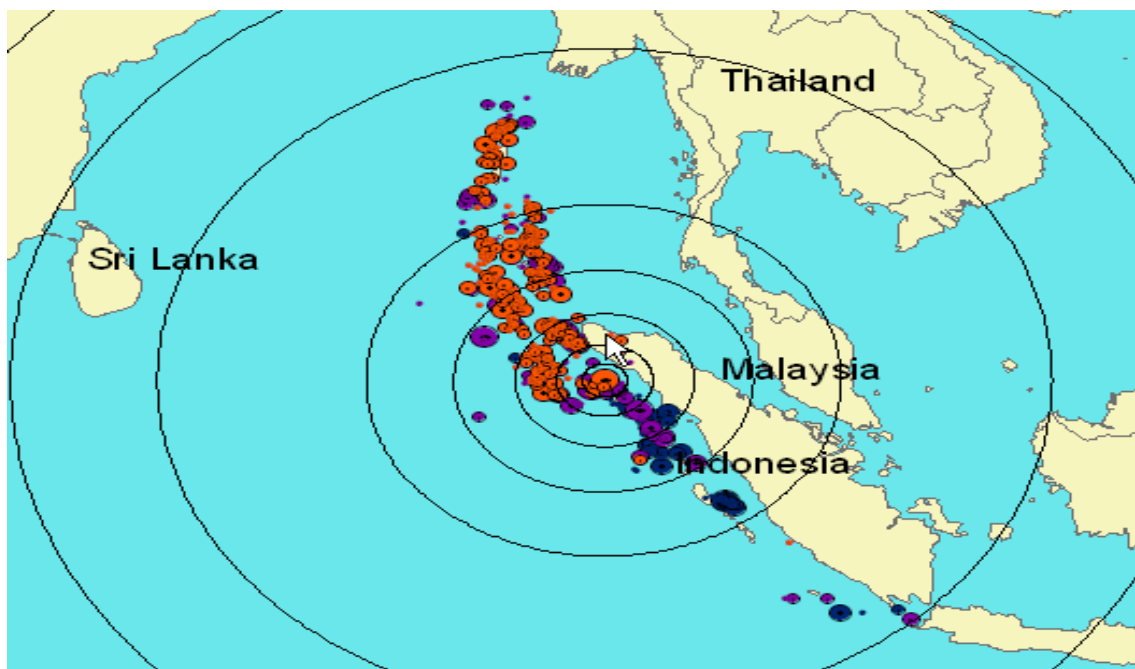
connections between location of epicentres, most recent earthquake activity and likely seismic gaps more easily. Figure 6.8 shows the attribute table that most pupils used to study earthquake pattern

**Figure 6.10** Earthquake attribute table in ArcGIS

FID	Shape*	YEAR	MONTH	DAY	TIME	LAT	LONG	MAG	DEPTH
0	Point	2004	12	26	005853.45	3.3	95.98	9.0	30
1	Point	2004	12	26	011710.33	4.94	94.27	5.5	30
2	Point	2004	12	26	012120.66	6.34	93.36	6.1	30
3	Point	2004	12	26	012225.59	7.42	93.99	6.0	30
4	Point	2004	12	26	012548.76	5.5	94.21	6.1	30
5	Point	2004	12	26	012952.94	20.91	97.71	5.8	38
6	Point	2004	12	26	013015.74	8.83	93.71	5.5	30
7	Point	2004	12	26	013322.38	7.76	93.71	5.5	25
8	Point	2004	12	26	014007.13	5.84	93.15	5.3	30
9	Point	2004	12	26	014852.07	5.43	94.46	5.7	51
10	Point	2004	12	26	015243	10.38	92.12	5.2	12
11	Point	2004	12	26	015913.99	8.39	92.45	5.3	30
12	Point	2004	12	26	020040.03	6.85	94.67	6.0	30
13	Point	2004	12	26	021523.57	6.17	93.47	5.6	30
14	Point	2004	12	26	021549.50	12.26	92.28	5.3	20
15	Point	2004	12	26	021559.78	12.32	92.5	5.7	26
16	Point	2004	12	26	022204.84	8.87	93.47	5.7	16

As I observed pupils using the data, it became evident that most were using the three distribution maps to locate likely seismic gaps. Figure 6.9 shows the most viewed map combination by pupils with the three series of earthquake activity plotted together. I made a note during the lesson to follow this up in forthcoming interviews with pupils (see section 7.3).

**Figure 6.11** Finding Seismic gaps



**Figure 6.12** Applying seismic gap theory- Summary

<p><b>Geographical aims</b></p> <ul style="list-style-type: none"> <li>To explore seismic gap theory</li> <li>To examine earthquake data sets in detail and to identify significant patterns</li> <li>To test seismic gap theory</li> </ul>	<p><b>Pedagogy</b>  <b>Geographical Enquiry</b></p> <ul style="list-style-type: none"> <li>To explore data and turn it into maps</li> <li>To analyse geographical information</li> </ul> <p><b>Geovisualisation</b></p> <ul style="list-style-type: none"> <li>Visualise key geographical features/examine their key characteristics/Make connections between visualised features</li> </ul>
<p><b>GIS processes</b></p> <ul style="list-style-type: none"> <li>Manipulation (joining data)</li> <li>Management</li> <li>Query (simple)</li> <li>Analysis (through simple overlay)</li> <li>Visualisation (via map)</li> </ul>	<p><b>Place constructs</b></p> <ul style="list-style-type: none"> <li>Earthquake period maps</li> <li>Joined attribute tables</li> </ul>

### 6.3.6 Introduction to Google Earth

In this lesson pupils were introduced to the basics of Google Earth. Several had used it outside of school before and were familiar with the basic functions that they needed to follow. This lesson started with the use of a satellite image of the area around the school. Pupils were encouraged to use the 'fly-to' function to locate their home postcode. At the beginning of the lesson they worked their way through the basic navigational tools rotating the screen mouse to change direction, 'gliding' in different compass directions, panning to the horizon and using the zoom facility.

In the second part of the lesson pupils measured their route from home to school and placed and described placemarks in their local areas. In the final part of the lesson I demonstrated how to zoom out from the local to the regional scale. Pupils completed the lesson by using the search function to identify a variety of famous landmarks and to switch on and off 3D views where these were available.

During the lesson, most pupils became quickly adept at using Google Earth tools. There were very few technical issues or need for extra support.

**Figure 6.13** Introduction to Google Earth – Summary

<p><b>Geographical aims</b> To study their local area via satellite imagery To study geographical features through 3D satellite imagery</p>	<p><b>Pedagogy</b></p> <p><b>Geographical Enquiry</b> To explore data and turn it into maps, tables, graphs To analyse geographical information</p> <p><b>Geovisualisation</b> Identify and explain geographical features, processes and patterns</p>
<p><b>GIS processes</b> Manipulation (simple) Management (using table of contents) Query (simple) Analysis (through simple overlay) Visualisation (via satellite imagery)</p>	<p><b>Place constructs</b> Place knowledge Place as site and connected attributes OS map Satellite image</p>

### 6.3.7 Earthquake and tsunami impacts (GE)

In this lesson pupils used Google Earth (GE) to study earthquake activity and the impacts of the tsunami. The lesson started with them viewing an animation hyperlink that had been geo-tagged to a location in Banda Aceh. Students then used the crowd-sourced community link data to view posted images of the tsunami aftermath. Pupils wrote a description of a number of the sites that they viewed and annotated these on their own Google Earth maps. Pupils used the community link tables and newspaper sources to name countries affected, distances from the main epicentre, the time that the tsunami hit local points on the map and the numbers of dead and injured by region.

Again, this lesson was noticeably different to the ArcGIS-based lessons because, in the main pupils seemed to experience less technical difficulty with using Google Earth. I noted in the lesson that although this was not surprising, it was significant and a point I would encourage pupils to explore in forthcoming interviews (see section 7.3).

In the final stage of the lesson, pupils used a number of news reports from the Google Earth community page to write an account of the key impacts of the tsunami.

**Figure 6.14** Earthquake and tsunami impacts (in GE) - Summary

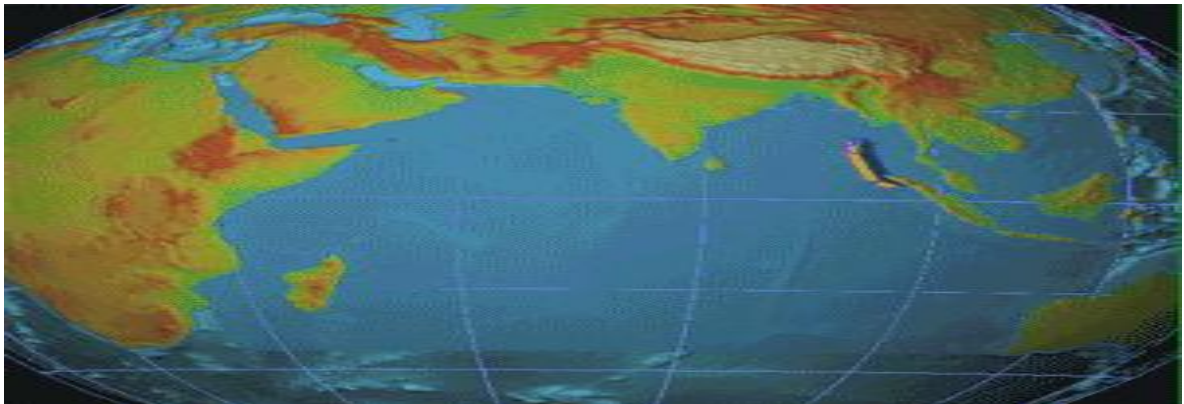
<p><b>Geographical aims</b>          To study earthquake distribution, tsunami distances travelled and areas affected          To identify major tectonic boundaries in the area          To name places affected by the tsunami          To measure distances travelled by tsunami waves          To relate location and date of earthquakes and tsunami to areas affected</p>	<p><b>Pedagogy</b>  <b>Geographical enquiry</b>          To analyse volunteered geographical information</p> <p><b>Geovisualisation</b>          Identify physical and human geographical features          Visualise key geographical features/examine their key characteristics          Make connections between visualised features</p>
<p><b>GIS processes</b>          Manipulation (of satellite image)          Management          Query (simple)          Analysis (simple)          Visualisation (via satellite imagery and placemarked photographs)</p>	<p><b>Place constructs</b>          Animation          Satellite image          Placemarked photographs</p>

### 6.3.8 Earthquake and tsunami impacts (hybrid)

This lesson began with my demonstrating to the class the variety of ways of using ArcGIS and Google Earth together to study earthquake activity and earthquake impacts. At the start of the lesson, before the class start to completing the mapping exercise in ArcGIS, several students opened up the tsunami animation in a separate window on their screens. I asked one student why he did this first (they had a task to do concerning the animation later on in the lesson). ‘Because it’s easier for me to see it miss’ he said. I sat and watched with him as he played the clip repeatedly; pointing out the countries that he could and couldn’t name: Sri Lanka, India. ...We discussed the smaller places that the waves travelled to and watched again...the Maldives, the island of Madagascar. He went back to ArcGIS – zooming out on the home screen so that he could see the East African coastline. He clicked on the identify tool and identified Somalia, Kenya, Tanzania and eventually, Yemen. As I watched he alternated between the two, watching the clip, comparing it to the map, panning over the countries

and labelling them. I explained to the class that this lesson they would combine their use of ArcGIS and Google Earth to completed their study on earthquake and tsunami impacts. As I observed pupils work using both, there was a clear distinction with pupils using ArcGIS for the more technical elements of the task, for example to map tsunami impacts, and using Google Earth to 'view' the same points in geo- tagged photographs at each of the sites. I made a note to pursue this observation in the forthcoming interviews with pupils (see section 7.3).

**Figure 6.15** Tsunami animation screenshot



[http://upload.wikimedia.org/wikipedia/commons/4/47/2004\\_Indonesia\\_Tsunami\\_Complete.gif](http://upload.wikimedia.org/wikipedia/commons/4/47/2004_Indonesia_Tsunami_Complete.gif)

**Figure 6.16** Earthquake and tsunami impacts (hybrid)

<p><b>Geographical aims</b></p> <p>To study earthquake activity and tsunami impacts via a range of geographical sources and in both ArcGIS and Google Earth</p>	<p><b>Pedagogy</b></p> <p>Geographical enquiry To explore data and turn it into maps, tables, graphs To analyse geographical information</p> <p>Geovisualisation Identify physical and human geographical features Visualise key geographical features/examine their key characteristics Make connections between visualised features</p>
<p><b>GIS processes</b></p> <p>Manipulation (of scale) Management Query (simple) Analysis (through simple overlay) Visualisation (via map)</p>	<p><b>Place constructs</b></p> <p>Map Satellite image Video Audio</p>



### 6.3.9 Tsunami variations at local and regional scales (hybrid)

At the start of the lesson, pupils studied the tsunami animation (Figure 6.15 alongside their ArcGIS base map of countries affected by the tsunami (Figure 6.3). I reminded pupils about the use of the fixed zoom function when studying the areas affected in greater detail (see Step 4, Appendix 3- Constructing the tsunami). Pupils selected 'target countries' both close to the main earthquake epicentre and at the furthest extent of the distance travelled by the tsunami. The remainder of this first part of the lesson was taken up with pupils comparing attribute tables of countries with deaths, injuries and the missing (see Steps 5 & 6, Appendix 3 – Constructing the tsunami).

In the second part of the lesson, pupils explore the size of wave run-ups on the Banda Aceh coastline. Some pupils place an overlay of the run-ups on the Google Earth satellite image (Appendix 3 – Google Earth). In the final part of the lesson pupils describe and explain the variations in tsunami wave sizes according to their locations.

**Figure 6.17** Tsunami variations at local and regional scales - Summary

<p><b>Geographical aims</b></p> <ul style="list-style-type: none"><li>To view the tsunami</li><li>To compare the tsunami path with the coast run-ups</li><li>To compare the impact of the tsunami at local and regional scales</li><li>To reach conclusions based on geographical evidence</li><li>To study tsunami impacts via a range of geographical sources and in both ArcGIS and Google Earth</li></ul>	<p><b>Pedagogy</b></p> <p><b>Geographical Enquiry</b></p> <ul style="list-style-type: none"><li>Exploring geographical data</li><li>Asking geographical questions</li><li>Analysing geographical information</li><li>Evidence-based decision-making</li></ul> <p><b>Geovisualisation</b></p> <ul style="list-style-type: none"><li>Identify physical and human geographical features</li><li>Visualise key geographical features/examine their key characteristics</li><li>Make connections between visualised features</li></ul>
<p><b>GIS procedures</b></p> <ul style="list-style-type: none"><li>Manipulation (of scale)</li><li>Management</li><li>Query (simple)</li><li>Analysis (through simple overlay)</li><li>Visualisation (via map)</li></ul>	<p><b>Place constructs</b></p> <ul style="list-style-type: none"><li>Map</li><li>Satellite Image</li><li>Video</li><li>Annotated photographs</li><li>Placemarks</li></ul>

### 6.3.10 After the tsunami

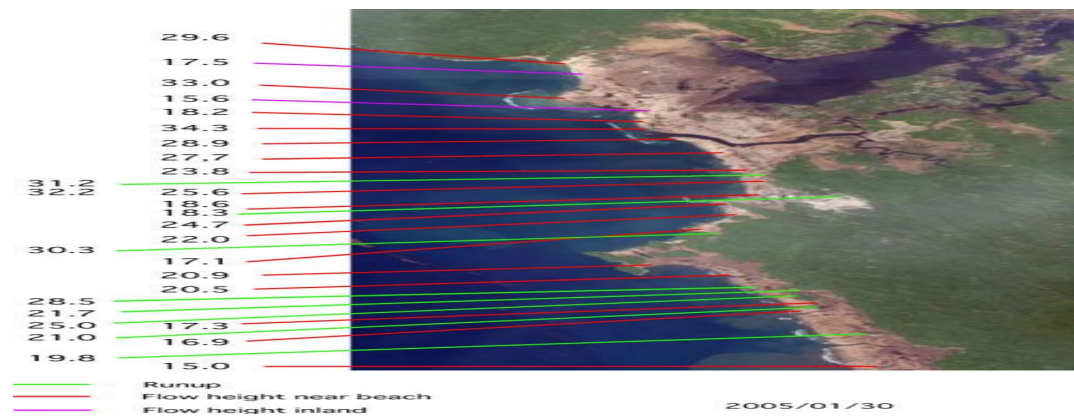
At the start of the final lesson, I explain to the class that this final and important part of their project is to write a description of what happened in Kamboja Street in downtown Banda Aceh since the tsunami. During the remainder of the lesson, I observed pupils using Google Earth, the ArcMap of the coastline and the audio and video clip to study the local urban area. Some pupils in the class also began to write summaries of their conclusions on the extent to which Kamboja Street has recovered from the tsunami.

**Figure 6.18** Banda Aceh Google Earth view



Pupils used Google Earth to explore survivors' accounts of the tsunami – examining satellite imagery, photographs before, immediately after and since the event. They study a variety of audio, written and visual media about Banda Aceh and surrounding villages on the tsunami-affected Sumatran coastline. They open their written interpretations of the tsunami impacts thus far and begin to add to their work using the survivor accounts. One pupil is using a diagram of the wave run-ups at Banda Aceh (Figure 6.19) and comparing them with the same part of the coastline as shown in the Google Earth satellite image (Figure 6.18). He measures distances from the main earthquake epicentre to the Banda Aceh coastline in Google Earth and adds the data to his overlay of the tsunami run-up times. He shows me the 'view' of the Banda coastline in 3D and zooms in fast to the nearest village. He re-plays the wiki animation of the tsunami waves stretching out across the Indian Ocean (Figure 6.15) time and time again. Most pupils view the Banda coastline in both ArcGIS and Google Earth by the end of the lesson, making notes about the impacts of the tsunami on Banda Aceh. I make a note to ask individuals about this particular exercise in forthcoming interviews (see section 7.3).

**Figure 6.19** Google Earth wave run-ups at Banda Aceh



**Figure 6.20** After the tsunami (hybrid) - Summary

<p><b>Geographical aims</b></p> <ul style="list-style-type: none"> <li>To view the tsunami aftermath and recovery operation</li> <li>To compare the tsunami path with the coast run-ups</li> <li>To reach conclusions based on geographical evidence</li> </ul>	<p><b>Pedagogy</b></p> <p><b>Geographical Enquiry</b></p> <ul style="list-style-type: none"> <li>Exploring geographical data</li> <li>Asking geographical questions</li> <li>Analysing geographical information</li> <li>Evidence-based decision-making</li> </ul> <p><b>Geovisualisation</b></p> <ul style="list-style-type: none"> <li>Identify physical and human geographical features</li> <li>Visualise key geographical features/examine their key characteristics</li> <li>Make connections between visualised features</li> </ul>
<p><b>GIS processes</b></p> <ul style="list-style-type: none"> <li>Manipulation (of scale)</li> <li>Management</li> <li>Query (simple)</li> <li>Analysis (through simple overlay)</li> <li>Visualisation (via map)</li> </ul>	<p><b>Place constructs</b></p> <ul style="list-style-type: none"> <li>Maps of Banda Aceh</li> <li>Satellite Image</li> <li>Video of 'A walk down Kamboja Street' (Guardian newspaper online)</li> <li>Annotated photographic image</li> <li>Placemarks</li> </ul>

## 6.4 Results of Analysis – Pupil interviews

In each of the sections that follow I discuss each of these key themes. The discussion is supported by extracts from pupil interviews and class documents. I discuss the GIS processes used during the geographical inquiry and the nature of place knowledge constructed as a result.

### 6.4.1 Geographical Integration

Geographical integration in 'Constructing the Tsunami' involved pupils in synthesising a range of geographical information about the tsunami and its impacts. The lesson descriptions and summaries show that the nature of this synthesis involved a number of distinctive similarities and differences with regards to each of the three types of GIS namely ArcGIS, Google Earth and the hybrid GIS.

First, data collected on the use of all three types of GIS used in the research emphasised the central GIS principle of joining geo-referenced information and displaying it in a meaningful digital representation e.g. a map or another form of geographical representation.

In each instance pupils used a number of spatial data sets including those on earthquakes, areas impacted by quakes and the effects of the tsunami (Appendix 3, Part 3). For example, in Lesson 2 where pupils used data layers to study the extent of the earthquakes occurring during the 2004-5 period and the areal extent of the 2004 2th December tsunami. In the following interview extract, pupils are discussing how they used ArcGIS to make these connections:

*Interview Group Sabrina, Jenna and Maya*

*Middle achieving girls; our discussion has been about the connections between using the data tables in ArcGIS and displaying them on a map of earthquake distributions.*

*Jenna: It's easier to see the earthquakes and put them on the map in ArcGIS (than in Google Earth)*

*Researcher: What do you mean exactly?*

*Jenna: It's simple to map, to plot them.*

*Sabrina: Like in.... looking at the causes.*

*Researcher: The causes?*

*Sabrina: Where the earthquakes happened, you can see it in the table and then you click and see/put the (earthquakes) layers on the map.*

*Maya: And we could zoom in close and out to see them (from a distance) with the proper window contents open.*

*Sabrina: And then we could plot them..... Accurately.*

*Researcher: How did that help you understanding what happened and where?*

*Sabrina: Because we could follow all the instructions and turn the clutter off.*

*Researcher: The clutter?*

*Sabrina: Yes, it made it easier, to analyse it, easier.*

In her writing about the pattern of earthquakes that occurred in the period of time after the main earthquake event on December 26<sup>th</sup>, 2004, there was clear evidence of Sabrina's careful scrutiny of the patterns of activity that she said could discern on the map. In her writing, she discussed the less than obvious pattern of earthquakes in an area to the west of the main earthquake activity in the 31/3/05- 11/5/05 time frame. She wrote:

*'Towards the west coast of Indonesia there were few epicentres scattered around – in no real order. They were also scattered around the smaller Indonesian islands.'*

On discussing the trends in earthquake data, she added:

*'As time goes on the magnitudes and the amount of earthquakes decreases substantially.'*

In her script, Jenna described using ArcGIS to predict seismic gaps. This group as a whole made a number of interesting comments about using GIS to look at patterns in the earthquake data. In particular, they highlighted being able to plot epicentres at specific locations, to follow directional trends of activity. Maya commented on being able to look at the distribution of earthquake epicentres at different mechanical scales, a characteristic cited by several students as later interview extracts in this chapter also indicate.

Another pupil, (David) wrote about using GIS to join data together and to relate common geographical trends:

*'We could see that around the time of the main earthquake after the tsunami on the 26<sup>th</sup> the pattern of earthquakes and aftershock started as a few big earthquakes all near the main epicentre. There were also many small tremors and aftershocks and we could see that these were mainly concentrated off the North-West coast of Indonesia and more towards the Indian Ocean'*

*(David, 'Constructing the tsunami', 2009)*

This interpretation of the earthquake timings and spatial distributions indicates that David had used the related tables in ArcGIS to compare locations and magnitudes of earthquakes. In a later excerpt he begins to make connections between where earthquakes have occurred in the past and where they are likely to occur in the near future (Seismic Gap Theory, Lesson 5):

*'In the next month and a half after the main earthquake, we predicted that the amount of earthquakes would rise and that they would have bigger magnitudes and more depth. They look like they are moving along the border of the Indo-Australia plate and the Indo-Chinese plate. So we thought that would mean more earthquakes along the west coast of Indonesia on the Indo-Australia side of the plate border?'*

*(David, 'Constructing the tsunami', 2009)*

In contrast pupils using Google Earth solely were less able to compare and analyse data in such depth. Information attached in Google Earth layers is surface deep and holds no associated attribute data. However, the data also revealed other significant contrasts. ArcGIS 9.0 was a product of its time (2008-9) when GIS software consisted of traditional map imagery with some (hot) linking to images and animations on the Internet, In contrast, where pupils were using Google Earth they had access to a much wider range of satellite imagery, video and audio sources.

#### 6.4.2 Place knowledge interpretation

In the lessons where pupils were using Google Earth and the hybrid (combining ArcGIS and Google Earth) there were some significant differences in the ways they interacted with place representations. Whilst pupils still followed a set of procedures based on Google Earth functions, there was much less in the way of their analysing data through strictly defined spatial querying or reasoning in a strictly defined 'spatial science sense.' Instead, the steps included:

- Loading and displaying Google Earth as an online satellite image viewer
- Using 'fly-to' features
- Viewing secondary data as a series of optional Google surface map layers which contained no underlying attribute data tables
- Reaching conclusions about earthquake pattern and impacts based on crowd-sourced information
- Measuring the distances travelled by the tsunami and impact variations
- Geo-tagging and uploading their perceptions of locations
- Overlaying wave run-ups on beach images of tsunami-affected areas
- Interacting with video and audio files

In the following interview extract pupils are discussing using both ArcGIS and Google Earth in the hybrid GIS:

*Interview Group Mark, Mishra and Jamie (Lower achieving group. talking about using the hybrid GIS):*

*Mark: If you do what it (ArcGIS) tells you to do, it's easy to see. But you need to follow the menus exactly.*

*Researcher: What did you find out?*

*Mishra: Lots of measuring. The patterns of the earthquakes it was very clear on seismic gaps.*

*Researcher: What was different about looking at places through Google Earth?*

*Jamie: You could see lots and lots of things you hadn't seen before? Pictures right along the plate boundaries. You just used two buttons to zoom in and then zoom out to look from (puts hands outwards) out here?*

*Mark: But ArcGIS you could see the epicentres it was clearer, more accurate? It was complicated at first but then it was very clever – I could think about two things on the map.*

*Researcher: The earthquake periods? Like the different groups, when they occurred?*

*Jemma: Yes. The menus made (it) easier to understand.*

This extract highlights another common characteristic of the interview conversations. Without any particular prompting, students seemed to know that ArcGIS was geared towards spatial analysis. Mishras' comment about the difference with using Google Earth to 'see pictures' was also representative of many of the interviews. Pupils were enthusiastic about being able to move from the largely map-based imagery in ArcGIS to the satellite imagery in Google Earth when using the hybrid GIS.

*Interview Group Dan, Jo and Eliot. High achieving boys ; our conversation has been about the relative experience of using ArcGIS and Google Earth in studying events around the 2004 South Asia tsunami . In the previous lesson the boys had used an online GIS as well as ArcGIS to study impacts of the earthquakes and the tsunami around Banda Aceh*

*Researcher: So you said that more than once that you had a different experience looking at Banda Aceh in ArcGIS today. Can you tell me what you mean? Different in which ways?*

*Dan: ArcGIS was much more helpful than the online one. It was much more straightforward to sort them (the earthquake strengths). And it made things really quick.*

*Researcher: And what about Google Earth?*

*Jo : It's easier to see things in it because you just type (a location) into the box and fly to it! Or you can just click on a video (on the place on the screen).*

*Researcher: Is Google Earth always easier to use as well as to study places?*

*Eliot: No, you have to centre it though and zoom in carefully.*

*Dan: And all the information isn't always there.*

*R: Which information?*

*Jo: It's not all 3D, doing (the looking in Google Earth) on the flat land isn't good.*

*Researcher: There are gaps in the image, in Google Earth?*

*Jo: Yeah, but you can see all the detail in 3D in the important places.*



*Researcher: Which ones are important?*

*Eliot: The ones near the big epicentres. ...And in ArcGIS you could see all the epicentres in all the different places.... You couldn't see that in Google Earth.*

*Researcher: So Google Earth isn't always easier then?*

*Dan: No. In ArcGIS you had all the information at the beginning...it was really easy to follow.*

*Eliot: And the spread of data.*

*Researcher: The spread?*

*Eliot: Across the days.*

In his written work, (where he was discussing how ArcGIS could be used to understand seismic gap theory, Dan stated:

*'It (seismic gap theory) could be applied because /due to the records, earthquakes hadn't happened (like this) for years. Also, if you look at the pattern, you can see that the earthquake lines follow the plate boundaries – they bend when the plates bend.'*

Eliot's comment about the 'spread of data' was backed up in his writing about how the pattern of earthquake activity changed over the six days between 26<sup>th</sup> -31<sup>st</sup> December 2004 in and around Banda Aceh. He wrote:

*'There were more earthquakes on the first day than on the rest of the days put together. As time went on there were less.'*

The conversation in this group raised a number of significant issues with regards to the students' perceptions of the value of using GIS to study the earthquake events in the area they are describing. Firstly, the view expressed by Dan throughout this part of the interview about the benefits of being able to display a range of patterns of earthquakes across areas and time phases in ArcGIS. He clearly appreciated being able to organise and sort the pattern of events an accurate scientific picture of locations, dates and sequences of earthquake activity. Eliot continued with this theme of being able to study spatial pattern and to identify 'seismic gaps' in

the data. Dan's additional comment about earthquakes 'bending when the plates bend' identified the same function of GIS fixing a range of data to and displaying it for particular locations.

Jo's comments about the 'wow' factor of Google Earth also indicate how virtual globes such as Google Earth can capture the imagination of students such as these. He was clearly impressed with the 'fly-to functionality' and the views that these gave him of particular (famous) places. It was also evident in this interview, however that students were of the opinion having completed the research study at this stage, that Google Earth as an earth viewer has less potential for spatial analysis than a more conventional GIS such as ArcGIS.

In the next interview extract the group are discussing the relative merits of using ArcGIS in comparison to Google Earth. They too identified the analytical strengths of using the 'system' of GIS study earthquake activity but were taken with the ability to move around in the realistic imagery of Google Earth:

*Interview Group David, Aaron and John High achieving boys ; conversation concerning using GIS to study earthquake activity around Banda Aceh, their experiences, likes, dislikes....they continued the conversation by discussing the hybrid where they integrated information from ArcGIS and Google Earth:*

*David: I sorted them (the earthquake distribution tables) so I could see when they happened.*

*Researcher: And where they happened?*

*David: Yes. And there were lots of (other) data you could measure, and see patterns in (in ArcGIS). It was really clear and accurate.*

*Aaron: Yeah but Google Earth is really clear – you only had to use two buttons.*

*Researcher: What did you use those (buttons) for?*

*Aaron: To zoom in and out on the epicentres. I'm not sure it's (Google Earth) is so accurate though. It's more interactive but not as clear on them.*

*Researcher: On them?*

*John: On the patterns... of the earthquakes.*

*Researcher: And 'interactive?'*

*John: It's (Google Earth) is clever because it looks real and you are able to move around more, it's less confusing.*

Several pupils commented on the advantages of combining ArcGIS and Google Earth whilst studying earthquakes and the tsunami during their lessons. Pupils had also used Google Earth to explore survivor's accounts of the tsunami – examining satellite imagery, photographs before, immediately after and since the event. They used a variety of audio, written and visual media about Banda Aceh and surrounding villages on the tsunami-affected Sumatran coastline. In this next interview extract the group are discussing working with both to compare impacts of the tsunami in Kamboja Street (Banda Aceh) in Lesson 10:

*Interview Group: Gabby, Deena, Nicole. Middle achieving girls; discuss comparing images and maps in hybrid GIS:*

*Nicole: We could compare pictures and other images about the tsunami.*

*Deena: Like the tsunami – facts that we couldn't know...didn't know in (Google Earth) we could see in ArcGIS*

*Researcher: Can you give me an example?*

*Gabby: We could sort the information (about the earthquakes) in the tables. It was good-being in control like that.*

*Researcher: In ArcGIS – the map?*

*Deena: Yeah, on the map.*

*Nicole: And we could move it to the side and look up... zoom and...*

*Gabby: Pan.*

This common theme of pupils identifying the advantages of using ArcGIS to analyse data and Google Earth to view places is evident in the next interview extract also:

*Interview Group Jamie, Brione and Dan; lower ability group discussing using hybrid GIS:*

*Jamie: Google Earth is so realistic; it was fun looking at new places. The image isn't live though.*

*Dan: No and it's not always updated*

*Brione: And I didn't like looking at earthquakes in Google Earth.*

*Researcher: Why?*

*Brione: I couldn't see the magnitudes; it's distracting because there's so much (on the screen in Google Earth).*

*Dan: It's better to do it in ArcGIS you can see them (the magnitudes) and where they are. I could locate them.*

*Brione: And the spread of the data.*

*Researcher: On the maps?*

*Brione: Yes in Arc...*

This extract also indicates that combining more conventional GIS such as ArcGIS with an earth viewer such as Google Earth can combine systematic analysis of geographical information with a range of satellite imagery and other visual tools to represent place.

## 6.5 Stage summary of findings

This stage of the research further shows the capacity of GIS to spatialise and visualise geographical information very effectively. Pupils used GIS to manage and manipulate a number of data sets about earthquake distributions and tsunami extents and produced maps to display these.

Geographical enquiry underpinned teaching and learning about place with GIS in the Constructing the Tsunami lessons. Pupils were introduced to the 'ask a geographical questions → acquire geographical resources → explore geographical data → analyse geographical information → act on geographical knowledge' cycle (ESRI, 2005) at the beginning of the first lesson and used the process throughout the sequence of ten lessons. The lessons involved pupils in querying data, transforming it into maps and graphs and developing evidence-based conclusions from the information they had gathered. Pupils carried out their investigations at two major scales in ArcGIS at the local and the regional. Pupils used maps, alongside satellite imagery to compare before and after photography of areas affected by the tsunami. Pupils also applied seismic gap theory using their maps.

In the Google Earth-based lessons, pupils carried out simple place marking and overlay processes to study their local area. Pupils used 3D imagery to view places where this was available and panned and zoomed in both birds eye and oblique views. Pupils used a number of Google Earth community linked resources to supplement their descriptions of earthquake and tsunami impacts.

In the lessons where a hybrid GIS was used, pupils studied earthquake and tsunami impacts in both ArcGIS and Google Earth. This involved their working with spatial analysis data in ArcGIS alongside, for example animations and news clips over the internet and with Google Earth satellite imagery. Pupils place a wave-run-up overlay onto the Banda Aceh coastline in Google Earth to measure run-up heights and impacts. Pupils annotated their images.

## Chapter 7 Discussion

### 7.1 Introduction

This chapter discusses the research findings in response to the main research question: *What role does GIS play in constructing relational knowledge about place in school geography education?* In previous chapters I have provided a context and rationale for the work (Chapter 1); presented a critical review of relevant literature in the field (Chapter 2); discussed the methodological rationale underpinning the research (Chapter 3) and analysed the classroom-based research (Chapters 4, 5 and 6) in relation to the three other key research questions:

1. *How does GIS influence teacher's practice?*
2. *How does GIS influence how teachers construct knowledge about place?*
3. *How does GIS influence how pupils interpret place?*

My central approach throughout this has been a critical engagement with the ways in which geography teachers construct knowledge about place with GIS and how their pupils can interpret place through GIS. I continue in the same vein in this chapter, drawing together the key empirical findings from Chapters 4, 5 and 6 and discussing them in the light of the conceptual review presented in Chapter 2 and the research questions. The empirical studies have yielded much to meet those original aims and provided some additional new insights.

Before I discuss the conceptual and empirical findings of the research together, it is as well to be reminded of the three key features of my supporting methodology because this is crucial to the way in which I will proceed with the discussion in this chapter. First, my methodology was aimed at steering the research towards 'thick description' (Geertz, 1973) of the use of GIS in schools by studying and reporting on teacher and pupil behaviour in context (Bryman, 2008). Second, my methodology was shaped by what Stake (1981) describes as "progressive focussing", that is in the particular instance of this research, moving from a broader focus on the role of GIS in affecting teachers' practice per se

(Chapter 4) to the more specific emphases on teaching and learning about place and relational readings of it through GIS (Chapters 5 and 6). Third, my methodology was dialectical throughout the course of the research, establishing connections between theory and practice.

In the opening chapter of the thesis, I indicated that my thinking on place and space had been influenced by a number of key works on contemporary human geography including Harvey's theorizations of space and place (Harvey, 1996; 2001; Massey's relational analyses (Massey, 1999; 2005); Soja's postmodern critique of space and Murdoch's poststructuralist interpretations of space (Murdoch, 2006). As I spelt out in those introductory paragraphs, the three research themes namely, *spatiality*, *relationality* and *pedagogy* also underpin the discussion that follows in this chapter.

In the conceptual analyses in Chapter 2, I emphasised the complexity and range of philosophical approaches to place and space in Anglo-American geography and called for more careful consideration of the latter in school geography curriculum making. I spelt out in particular the nature of place and space knowledge constructed through spatial science (the paradigm through which GIS originally emerged). In connection with the latter, I also highlighted the way in which spatial science approaches founded in academia during the 1960s and 70s had filtered through to some schools and set the scene for a 'new school geography' of systems and analyses based on the spatial concepts and modelling that still lie at the heart of most geographical information systems. I also emphasised the role of early GIS in promoting the use of quantifiable geographical data and positivistic routes to enquiry in a form of geography as a discipline which seemed to view its self or indeed aspire to being a bone fide science (Unwin, 1992). I discussed at length the spatial science critique which emerged in geography academia (in the 1970s and the 1990s in particular) with a view to teasing out the significance of more complex interpretations of spatiality in constructing place knowledge in geography classrooms. I claimed that teachers using GIS needed to be more aware of the possible *dissymmetry* (poor fit) between the limits on knowledge construction in GIS and wider approaches to teaching and learning about place in school geography.

In relation to this argument, I made a further case for school geography teachers and teacher educators being more critical in their consideration of the ways in which all geographical spaces reflect the ontologies and epistemologies underpinning their creation (Dear and Flusty, 2002). In my critique, I drew on a number of works on the nature of space and place in geography. For example, I discussed Soja's postmodern three-part analysis of spatiality as *First, Second and Thirdspace* to consider further the social construction of space and place through GIS more closely. As my analysis

indicated (p 42), Soja's work (dating back to his first book: *The Geography of Modernization in Kenya : A Spatial Analysis of Social, Economic and Political Change (1968)*) reflects his scepticism about the concepts underpinning spatial science analysis in the 1970s and 80s and positivistic approaches per se in the social sciences since (Latham,2004). Soja questioned the predominance of historicity and sociality at the expense of spatiality in the construction of knowledge. His approach influenced my thinking about the construction of space in GIS in several ways. Where he questioned the 'realist illusions' and 'presumptions of scientism' (Soja, 1996, p76) in the use of geographical information systems, I became interested in observing and interpreting the influences of these kinds of epistemologies in the construction of school geography. In the remainder of this chapter, I discuss the empirical and conceptual analyses in response to the main research questions. The discussion begins with close consideration of the key overall influences of GIS on teacher practice.

## 7.2 The influences of GIS on teacher practice

In Section 2.5, I discussed how previous research on GIS in school geography has been characterised by three significant foci: The role of GIS in the development of spatial thinking (Kerski, 2003; Lee and Bednarz, 2009); the nature of enquiry learning through GIS (Keiper, 1999; Fargher, 2004,) and the technological and pedagogical challenges facing teachers using GIS (Kerski, 2003. The conceptual and empirical analyses clearly support the significance of those earlier studies with regards to the way in which GIS influenced teacher's overall practice. To summarise, the key findings from my analyses are:

- Teachers use GIS to visualise spatial patterns in teaching and learning
- Teachers use GIS to make connections between spatially-referenced data sets
- Teachers employ mainly closed enquiry strategies in teaching and learning with conventional GIS
- Teachers using hybrid GIS employ more open-enquiry strategies with GIS
- Teacher's GIS experience and expertise has a major influence on their GIS practice

In the discussion that follows I discuss each of these main findings from the analyses in detail.



### 7.2.1 Visualising the spatial

As Schuurman (2004) has argued, one of the main advantages of using GIS in geography is its capacity to make spatial relationships visual. This research also shows that using GIS to make spatial patterns visual in geography teaching and learning was a common feature across each of the empirical stages. The key difference highlighted was the contrast between visualising spatial patterns in conventional GIS in comparison to visualising spatial patterns in an earth browser such as Google Earth. The findings showed how all three types of GIS (ArcGIS, Google Earth and the hybrid GIS) could be used to display locational information and spatial patterns about earthquakes and tsunami impacts (Section 6.4). However, whilst conventional GIS is used to map and display locational data and to visualise distributions, earth viewers have none of the latter's analytical capacity (Goodchild, 2008).

This difference in functionality was evident in the way teachers used GIS. In their discussion on mapping through ArcGIS, Sinton and Bednarz (2007) describe how mapping through GIS can help pupils become more spatially aware. This element of using GIS was evident in all of the teachers' commentaries where they used ArcGIS to map, display and analyse spatial patterns. In the example of David's case study (Section 4.1) where he exhibited 'expert knowledge' in using GIS, he showed how he used GIS to map urban heat islands and to display the results of environmental surveys and pedestrian flow analyses. Similarly, Mike and Simon's case study (Section 4.3) showed how they used GIS in a range of different ways from mapping 'core geography knowledge' at Key Stage 3 to mapping variations in microclimates at A Level. In Year 7 they used GIS almost as a digital atlas to support pupils exploring the world map and learning about the basic rudiments of latitude, longitude and time zones (Section 4.3.2). Eleanor (Section 4.4) identified the key role that the Dakini GIS mapping project<sup>14</sup> had on providing digital Ordnance Survey maps to support local fieldwork. Sandra and Julie (Section 4.5) worked with a GIS consultant to map local fieldwork around the London Olympic Park.

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<sup>14</sup> The Dakini Project made a range of OS-based data available for schools in Kent and the NW of France between 2005-7

Since the advent of earth viewers such as Google Earth, many teachers have used these as alternatives to more complex GIS programmes and evidence from this research also supported that trend. Earth viewers can be used as geobrowsers to display satellite imagery and to move around in large scale geographical space as if though it were small scale and manipulable ((Butler, 2006). The less experienced Spatially Speaking teachers used online earth viewers with local council data to support fieldwork mapping in this way. Jenny and Marco (Section 4.2) used Google Earth to support their local fieldwork. The ease of use of Google Earth and its visualisation capacities make it an attractive alternative to more complex GIS even if its functions are rather more restricted in terms of the layers of information it can display (Goodchild, 2008).

With regards to the use of hybrid GIS, (Section 6.4.1) ArcGIS could be used to display multiple themed layers about earthquake periods, tsunami impacts, population distributions and other geo-referenced data, Google Earth was used to display base imagery and elevation data of affected areas with overlay layers made transparent and placed over these (Section 6.4.1). The latter images were visually aesthetic but were not linked to any underlying GIS analytical capacity (Goodchild, 2008). This was evident in how teachers applied GIS. Visualising locational data in ArcGIS was associated with detailed map display which pupils could interact with in order to carry out spatial analysis (Sections 5.1 and 6.4). In Google Earth, teachers used its visualisation properties to 'fly to and view' locations for simple site analysis and to display some distributions of geographical data.

### 7.2.2 Making connections

There was an obvious correlation between the breadth of experience of using GIS and teachers' understanding of the processes involved in geographical integration through GIS (Section 4.1-7). The more experienced Spatially Speaking teachers made lengthy reference to using GIS to 'make connections' in geography. In his description of using GIS to collect and analyse weather data David (Section 4.1) explained how his pupils combined primary data collection through GPS in their fieldwork with desktop GIS in the classroom. In another example, David described how another class of pupils mapped the spatial patterns in their primary data and then used Nearest Neighbour Analysis to study clustering and dispersion of businesses in their city (Section 4.1.2).

Mike and Simon (Section 4.3) reported more specifically the advantages of using GIS to collect large amounts of fieldwork and to be able to process this quickly and efficiently. They commented on the educational value of being able to use this kind of integrated data to inform their pupils' geographical discussions. Mike and Simon also discussed the value of using GIS to integrate online data with links to physical databases and 'embedded'<sup>15</sup> video and map data (4.3.2). In another example, Mike and Simon explained how they had combined a digitised paper map with GPS to allow pupils to link their location with and to record data for a local field project on land use via the 'digital equivalent of a clipboard' (4.3.2).

When I observed John in the Mapping the Land sequence of lessons (see section 5.5.3) he repeatedly reminded his pupils about why they were using GIS to process data. He taught them how to 'join and relate'<sup>16</sup> in ArcGIS so that they could compare different data sets about their local area and choose which of these they wanted to display and analyse in their project work (Section 5.5.3). As I noted in Section 5.5.3, another key element of the integrational processing of data that John carried out with his pupils was the process of aggregating data, a sophisticated process which allowed pupils to bring layers together for specific areas e.g. census wards. This led to quite complex comparative analysis of their primary fieldwork data and previous census data for these areas (Section 5.4.4) which was both appropriate and rigorous for the hypothesis testing John had planned.

The findings from the Constructing the Tsunami teacher lessons at School B also showed how GIS was used to make connections in geography lessons (Chapter 6). Teaching was set up to support pupils understanding of earthquake patterns and tsunami impacts by combining sets of spatially-referenced data (Section 6.4). In the conventional GIS lessons, desktop ArcGIS was used to display earthquake distributions and earthquake impacts on maps at different scales and to display activity at different time periods (Section 6.4.1)<sup>17</sup>. The lessons taught on the application of seismic gap theory demonstrated clearly the role of conventional GIS in integrating different layers of spatially-referenced data. Geographical integration in ArcGIS involves four main types of combining of information. First,

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<sup>15</sup> Embedded data is integrated into a GIS map or satellite image

<sup>16</sup> Join and relate refers to processes which connect data sets in GIS

<sup>17</sup> It is important to consider the timing of the data collection for this stage of the research (2008-9). At that time the version of ArcGIS available for me to use in schools (ArcGIS 9.2) had limited satellite imagery functionality or interactive capacity with the Internet unlike ArcGIS online (2012-).

differently themed data sets can be stored in a GIS database. However, true geographical integration which could be described as a cornerstone of more holistic thinking about place and where data is actually merged seamlessly is very difficult to achieve in conventional GIS because the GIS system separates data into distinct layers (Harvey, 1997).

### 7.2.3 Enquiry-based learning

Palmer et al (2008) describe how enquiry learning through GIS as a research method allows learners to see the world in spatial terms. The process involves exploring, analysing and acting upon geographical knowledge. As I discussed in Section 2.10, there are five key steps to the enquiry procedure most commonly used with GIS in school geography. The 'ask a geographical question→acquire resources→explore data→analyse information→act on geographical knowledge' model can be applied in an unstructured or a more structured way (Bednarz, 2000). Teachers in the Spatially Speaking project using ArcGIS (see sections 4.4-4.9) expected pupils to use GIS as active learners and engage in activities that Van Joolingen et al, 2005 described as acting 'like researchers do' to develop their own knowledge ( Favier and van der Schee, 2012).

In particular, there is a specific argument made by advocates of GIS use in education that this approach has the potential to change geography education for the better because it can be used to provide means of accessing and analysing geographical data that can support deeper geographical understanding (Baker & White, 2003; Kerski, 2003; Sinton & Lund, 2007). In Section 2.10, I discussed the ways in which GIS has been described as a driver of enquiry-based learning because it allows pupils to visualise, manipulate and analyse digital geographical data in an efficient and flexible way ( Favier and van der Schee, 2012). The findings of the research analyses support the argument to be made for geography education that enquiry learning through GIS can allow for digitally-resourced geographical enquiry than would not be possible by more conventional means (Sind and Lund, 2007). This is the case for more conventional GIS such as ArcGIS desktop (Sections 4.1-6 and 5.4) and the newer earth viewers such as Google Earth and the hybrid GIS used in the Constructing the Tsunami lessons (Section 6.4).

As I discussed in Section 2.10 there is another significant argument that can be made about using more conventional GIS in enquiry-based learning. The use of GIS in geography education can be characterised by the adoption of very specific spatial thinking procedures and a commonly applied 'GIS enquiry' approach which can lead to quite prescriptive learning unless teachers are aware of these kinds of limitations. Evidence suggests that to be truly effective EBL requires teachers to think very carefully about pedagogical strategies (Roberts, 2013). With GIS, successful enquiry learning involves careful choices about selecting more closed or open approaches (Bednarz, 2000). In this research, John's work in *Mapping the Land* clearly reflected this kind of critical use of GIS, where he was very aware of its potential constraints on geographical thinking, but where he made the assumptions made in GIS transparent both in his teaching and his pupils' learning (see Section 5.2).

#### 7.2.4 GIS challenges for teachers

Mishra and Koehler's TPACK model (2006) and the findings reported by teachers in this research suggest that GIS-related curriculum innovation requires teachers to develop their pedagogic strategies in a number of complex ways. Chapter 2 reported on the challenges experienced by teachers and their students of using technically demanding conventional GIS not specifically designed for use in school education (Bednarz and van der Schee, 2006). In particular it noted that successful GIS-supported pedagogies in geography education are more likely to occur through a better understanding of the influence of teacher's technical pedagogical content knowledge (TPACK). This was most obvious in the teachers' written reports where most cited the important influence of training on their GIS practice. Successful use of GIS often depends on a critical mix of critical teacher geography content knowledge *and* GIS technical knowledge.

Lack of experience and training remains a major hurdle for teachers wanting to use GIS in geography lessons. There is a recognised connection between teacher's experience of using more complex GIS and their practice with GIS in the classroom (Bednarz and van der Schee, 2006). To date, successful use of GIS has been limited to only a small number of schools, (Ofsted, 2011). The small uptake in its use has often been connected with the fact that many teachers continue to associate GIS technologies with a steep initial learning curve and costly training (Fargher and Rayner, 2011). The teachers' experiences of fulfilling these two main educational aims varied directly according to their

GIS expertise. When the methods of visualising spatial patterns and connections and developing pupils' geographical enquiry were examined more closely through the interviews and in the teachers' written reports, there was a clear distinction between the more experienced and less-experienced GIS users.

The less experienced users cited the limitations of not being able to use what they perceived as more complex GIS such as ArcGIS to support geographical teaching and learning (cf Kerski, 2003). The more experienced reported on their experience of what Mishra and Koehler (2006) describe as 'Technological Pedagogical Content Knowledge' (TPACK) (Section 2.10) where they were able to use past experience and GIS training to combine GIS technological competency, pedagogical skills and expert geography subject knowledge combined.

David's case study (Section 4.1) showed that his considerable experience of using GIS in the classroom and his role as a GIS teacher trainer led to his being able to use his 'expert knowledge' to bear on supporting geography teaching and learning. Eleanor's case study (Section 4.4) showed that combining GIS training with Ordnance Survey resources for her local area helped her to apply the kind of 'knowledge that expert teachers bring to play' with GIS in the way that Mishra and Koehler describe (2006, pg.15). On the other hand, in Jenny and Marco's case (Section 4.2) they identified the barriers to implementation of GIS in their school partly through their own lack of training with GIS software that needs to be more specifically addressed for school teachers wishing to implement GIS in their schools (Bednarz and van der Schee, 2006).

The Jenny and Marco case and the reports from the other less experienced users of GIS amongst the Spatially Speaking group (see Sandra and Julie, Section 4.4) indicated that where teachers could not access the complexity of more conventional GIS software, they used online viewers as a substitute. The latter choice had implications for how teachers could use GIS to support geographical teaching and learning as the further discussions below indicate.

### 7.3 The influences of GIS on teachers' construction of knowledge about place

The empirical analyses in Chapters 5 and 6 alongside the literature reviewed in Chapter 2 showed that GIS influenced how teachers constructed knowledge about place in two main ways:

- Teachers used site analysis as a key method in constructing place knowledge
- Teachers used GIS to map and connect locational information about places

#### 7.3.1 Site analysis

In the introduction to this thesis I discussed the central role of the concept of place in geography and geography education (Section 1.1). I identified that one of the key approaches to interpreting place is through studying the nature of place through its location. Harvey (1997) argued that GIS has a central role to play in bringing together geographical information and fixing its significance at geo-referenced locations. It is geographical location and not place which a GIS focuses on. The research analyses reflect the ways in which teachers used this focus on location to carry out site analyses in teaching with GIS. In Section 7.4 I discuss site analysis more fully with specific reference to place interpretation through ArcGIS, Google earth and hybrid GIS.

#### 7.3.2 Mapping and connecting locations

Displaying locational information through mapping is a fundamental element of teaching with GIS (Virdi and Kulhavy, 2002; Javier and van der Schee, 2012). The research analyses reflect the central role of mapping locations when teaching about place through GIS. GIS has a key role to play in bringing together and displaying geographical information about inter-related places (Cope and Elwood, 2009). The research findings show that teachers used GIS to develop their pupils' understanding of geographical context and the interconnectedness of place(s). Despite some physical limitations of representing geographical phenomena through GIS, the analyses show that

most teachers used it a powerful medium for making connections between geographical data bases (Sections 4.2, 5.4 and 6.4). Teachers also used the GIS layer model<sup>18</sup> to store information about places in thematic layers which could then be linked together in their geography lessons. The thematic layer approach is a cornerstone of GIS display, allowing the user to organise complex real world data into a simple representation that can help to connect geographical information (Buckley, 1997).

#### 7.4 The influences of GIS on pupils' interpretations of place

Physical representation of place (and other geographical phenomena) in GIS is constricted by the technological constraints of the system being used. This proved to be the case in the use of conventional GIS, a virtual globe and the hybrid form of GIS used in the research. It followed that the more prescriptive the processing of data required in the system, the more rigid and closed the type of teaching and learning about place resulted. The use of more conventional GIS such as ArcGIS can support some forms of relational understanding about place, although this tends to be limited to interpreting relations between largely quantitative data. Early in this research, with regards to the influences of GIS on pupils' learning about place, I raised the question: *How does thinking in these very specifically structured and deterministic ways influence how individuals construct knowledge about place?* The research findings show that GIS has very distinct influences on how pupils interpret place particularly with regards to relational readings of it. In this section I discuss its influences with regards to the use of the 'conventional GIS' (ArcGIS) and a hybrid (combining ArcGIS and Google Earth). Findings discussed in Chapters 5 and 6.

##### 7.4.1 Place interpretation through ArcGIS

In Section 2.10 I discussed the very specific nature of spatial thinking through conventional GIS. I argued that this kind of spatial thinking originated from the tenets of spatial science and rooted in the understanding of the physical properties of GIS space, the use of GIS tools of representation and a distinct set of reasoning processes. Spatial querying and reasoning; measurement, optimal location

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<sup>18</sup> The GIS layer model is the framework of layers of geographical information in a GIS



theory and hypothesis testing using inferential statistical tools tend to dominate how data can be used within a GIS (Longley et al; 2005). Schuurman's critique of GIS spatial practice (2004) summed up the nature of this approach. She argued that GIS users often match the capabilities of the technology to the subject matter that is to be investigated through GIS (Schuurman, 2004). These types of spatial thinking are particularly well-suited to a very specific type of enquiry learning through GIS, one which mirrors closely the fundamental structure of a geographical information system. It can be argued that GIS supports deeper learning about spatial patterns (Sinton and Lund, 2007). This framing of knowledge has considerable ramifications for teaching and learning about place in the classroom. Research findings from the 'Constructing the tsunami' stage of the research (Chapter 6) also supported the claim that place interpretation can be limited by the narrow range of functions that pupils can use in GIS. The findings of the research also suggest that this can also involve there an overbearance of looking for visual repetition and correlation (See Sections 5.5.4 and 6.6.4). However, an argument can also clearly be made for using the very distinct procedures of GIS to structure geographical enquiry in schools, as each of the three empirical studies have also indicated.

For example, pupils in the *Constructing the tsunami* stage of the research using conventional GIS explored a range of complex but largely quantitative data sets. They constructed ordinal data when ranking the earthquakes according to magnitude, interval data when comparing episodes of earthquake activity and interpreting ratio data when measuring distances between epicentres. They identified a series of locations (declarative knowledge), they then follow a number of highly prescribed GIS procedures to navigate across the map screen (panning the image to determine directional trends in epicentre pattern); they assimilated 'configurational knowledge' making a series of links between spatial science relations. The knowledge constructed is relational to the point where connections between mapped structures in the GIS can be made and described (Section 6.4).

The Mapping the Land' data revealed the important role of conventional GIS as a very effective mapping and analytical tool. This rigorous and highly-structured process involved them in constructing place knowledge through a set of stringent spatial querying. This allowed them to explore, analyse and map local sites and land use variation. However, this 'logic of the map' (Harley, 1989) also tended to restrict the ways in which pupils were able to discuss place. Place became expressed as a site of relations between sets of attribute data stored and mapped in GIS but is also strongly determined by an underlying positivistic philosophy.

Schuurman (2004) raised further important questions in connection with this kind of positivistic approach to constructing geographical knowledge. A central tenet of positivism is that observation precedes theory and that in logical positivism in particular that knowledge constructed about the world needs to be verifiable in a scientific way. The research findings indicate that pupils learning about place through this kind of spatial science-based enquiry resulted in rigorous scientific site analysis (see Sections 5.4 and 6.4) but also spatial thinking about place which can become dominated by these rather closed procedures. Whilst the research findings show evident educative advantages of pupils being able to capitalise on the scientific analyses available through GIS, there are potential shortcomings of looking at place through a conventional GIS lens. The positivism behind GIS was also reflected in the ways in which pupils learnt about place because teachers used deterministic reasoning and quantification to underpin lessons. For example, learning about land use in the 'Mapping the Land' research findings involved 'measuring variables,' 'identifying anomalies,' 'correlating pattern.' This is geography education with GIS framed by largely by hypothesis –testing, prediction and scientific 'problem-solving.' Pupil interviews in 'Mapping the Land' and 'Constructing the tsunami' also showed a certain type of 'language of GIS' that pupils communicated through (Section 6.4). Their discussions about the places they studied, though detailed and based on their intricate analysis of detailed data sets were largely confined to descriptions of the quantifiable and spatial correlation.

One viewpoint on this type of knowledge construction in the Geography-GIS classroom is that this is also the inherent success of GIS in that its scientific procedures can be capitalised on in terms of developing spatial literacy (NRC, 2006). This research supports that view in so much that pupils using GIS did develop their spatial skills. However, the research findings suggest that there are limits to framing place through this kind of scientific deductive reasoning. The conventional GIS (ArcGIS 9.2) used during the research was simply not very good at representing more open-ended social phenomena for pupils when compared to the use of hybrid GIS in particular (see Figure 7.1).

#### 7.4.2 Place interpretation through Google Earth

Section 2.8 discussed how Google Earth does not use methods that are so completely different from those used in conventional GIS. What does make geobrowsers such as Google Earth special,

however is the ability to see who took pictures in and around a place, with blog entries and geotags which provide a providing a very different experience of place. In Section 6.3.10, I described how 'A walk down Kamboja Street' allowed pupils combining immersive visualization (through Streetview in Google Earth) with their developing their procedural geographic knowledge of that particular location in Banda Aceh. Pupils explored Kamboja Street and the areas around it and 'geo-tagged' their written descriptions into Google Earth. The potential for the individual pupils' engagement with the represented data can go beyond the kind of 'metadata' restraints exhibited in more conventional GIS (Section 2.8). Whilst geobrowsers cannot capture the specificity of place completely they can 'picture' more elements of it than conventional GIS. This provides pupils with more qualitative information that can be seen in the form of text, audio, video, images<sup>19</sup>.

#### 7.4.3 Place interpretation through hybrid GIS

In section 2.10, I spelt out the key role established in schools using GIS for using enquiry to develop spatial literacy, based on 'exploring geographical space' through GIS (Sinton and Bednarz, 2007). The *Mapping the Land* and *Spatially Speaking* data re-enforce the well-established role of GIS as a very effective mapping and analytical tool in school geography (Alibrandi, 2003; Kerski, 2003; Doering and Valetsianos, 2008). Pupils' interpretations of place through ArcGIS also reflected these strengths with regards to mapping locations and site analysis. For example, it was clear when I interacted with Johns' pupils (see section 5.3) that many of them were very adept at using GIS in spatial analysis on their local town. There were instances in my lesson observations of the class where pupils were able to both use GIS to integrate and visualise their data and talk very fluently about spatial patterns (see section 5.5.3). These types of spatial thinking are particularly well-suited to a very specific type of learning through GIS, one which mirrors closely the fundamental structure of a geographical information system (Mark, 1993). Pupils were able to follow a route of enquiry with very clear stages where large amounts of geographical information could be manipulated and analysed within a GIS. The findings show pupils being able to reach well-informed decisions based on geographical information, as, for example the descriptions in *Mapping the Land* about Bishop's Stortford (as section 5.5) and *Constructing the tsunami* about the Banda Aceh region in south Asia (as sections 6.3 and 6.4) illustrate.

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<sup>19</sup> It is important to note that at the time of writing, more conventional GIS software providers including ESRI the commercial producers of ArcGIS have recently produced their own version of an earthviewer: AecExplorer that functions in much the same way as Google Earth

In terms of relationality, there are limits to the kinds of geographical knowledge that can be constructed through this kind of thinking. The implications of the way in which space has been thought out in GIS is of considerable importance when considering how teachers and their students using the technology can conceptualise place through it. If the essence of a post-structuralist relational reading of place is embraced, then rather than relations being an effect of structure (as GIS often represents it) then structure is an effect of relations (Murdoch, 2006).

However, as the analyses of *Constructing the tsunami* indicate, there are ways in which GIS can be used to broaden its' educational scope and for it to be used more effectively to represent place in geography classrooms. As I argue in the final chapter of this thesis, by building on the scientific rigour of conventional GIS and including more open approaches to teach about place through virtual globes, teachers can begin to capitalise on both types of geo-technology in school geography. With this point in mind, this part of the discussion of findings now turns to pupils' place interpretations through an adapted, *hybrid GIS*. In his 1997 article: *'From geographic holism to geographic information system?'* Harvey discusses how hybrid approaches to using GIS can bring together a holistic and systems based approach to understanding geography through GIS is feasible and allows for better understanding of place in GIS. In applying a similar approach in this school-based research, pupils in *Constructing the tsunami* were able to combine spatial analysis in ArcGIS with 'earth-viewing'<sup>20</sup> in Google Earth.

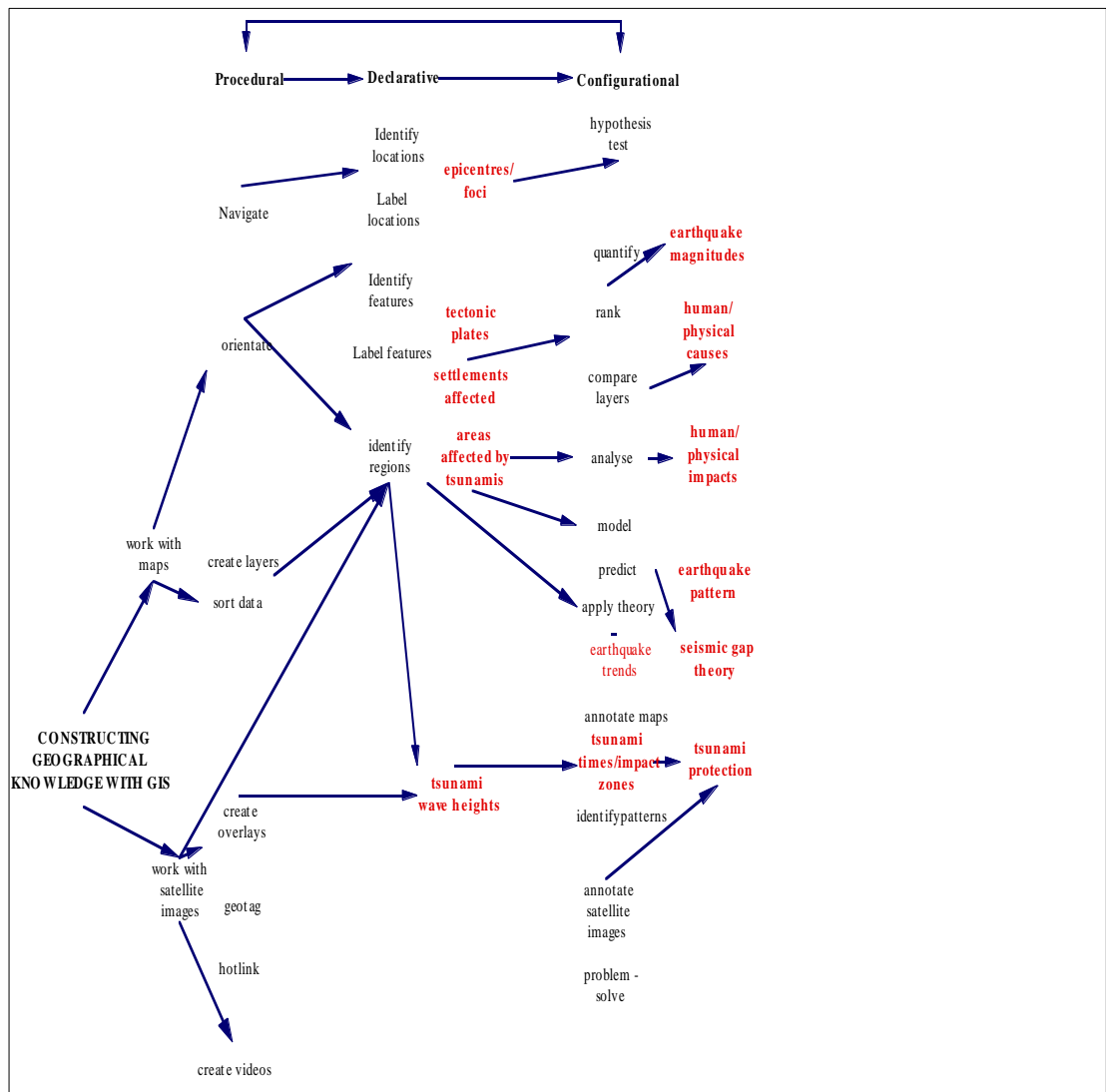
Figure 7.1 maps the ways in which geographical knowledge about the tsunami was constructed in the hybrid GIS lessons (sections 6.3.8-10). These particular lessons came at the end of the ten week teaching period in the research when pupils were quite well-established in their use of ArcGIS and Google Earth. The process involved them in a wide range of learning from locating and labelling places to deep analysis of seismic gaps using ArcGIS. Pupils used a range of mapping and analytical tools within the hybrid GIS to develop their knowledge and understanding of the physical causes of the event and the human impacts of the disaster. This element of their study harnessed the traditional strengths of 'conventional GIS' in constructing knowledge of place through prediction, enquiry and problem-solving as the lesson observation and pupil interview analyses in Chapter 6 (6.3.8 – 6.3.9; 6.4.1-2) indicate. As pupils became more confident with the combination of using the more conventional software alongside Google Earth, they began to move quite seamlessly between the two, navigating across the two sets of digital geographical space and choosing which to work with.

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<sup>20</sup> 'Earth-viewing' is interpreted in the context of this research as using a virtual globe

As Figure 7.1 indicates, they were able to develop their procedural and declarative knowledge and carry out a range of quite complex configurational procedures. It also allowed them to use Google Earth to explore their geo-tagged information on places affected by the tsunami. They studied a variety of audio, written and visual media about Banda Aceh and surrounding villages on the tsunami-affected Sumatran coastline and interdependent connections of places more further afield.

Figure 7.1 Map of geography knowledge construction in hybrid GIS



In the data, pupil commentaries suggest that the combination of ArcGIS and Google Earth may stimulate geographical imaginations and utilize the analytical power of GIS in tandem. The essential characteristic of this approach is the combination of the analytical systems approach in ArcGIS and

the more open-ended use of the Google Earth viewer reminiscent of Harvey's holistic/systems approach to thinking geographically through GIS (Harvey, 1997). The evidence supports the claim that hybrid GIS can combine the scientific rigour of more conventional GIS with more open concepts of place and high quality visualisation, particularly with regards to satellite imagery.

## 7.5 Summary

This chapter has discussed the conceptual and empirical findings of the research together. It has discussed the findings of each of the research questions in the light of the key literature on the representation of place and relational thinking in GIS and the role of GIS in school geography. The discussion has identified the role of GIS in supporting teaching and learning about place in school geography. In particular, it has considered its influence on teachers' practice and pupils' interpretations of place. The discussion has acknowledged that GIS has an important role to play in constructing place knowledge in the geography classroom but that the representation of place through GIS is also partial and strongly influenced by the positivistic underpinnings of GIScience. The chapter has also established that this research has sought to closely explore and demonstrate the nature of teaching and learning processes and place knowledge created through the use of GIS in the geography classroom.

The discussion on teachers' practice with GIS revealed that GIS has an important role to play in visualising spatial phenomena, making spatial correlations, 'earth viewing' and supporting enquiry-based learning in school geography. Alongside these important elements of influence, GIS can also provide considerable technological and pedagogical challenges for teachers. The chapter also revealed that GIS is used mainly by teachers in three specific ways to support their classroom practice: to carry out site analysis, to map locations and to connect data about places.

The discussion on pupils' interpretations of place through GIS revealed the different influences of conventional GIS, Google Earth and hybrid GIS. Place interpretation through conventional GIS is dominated by a very particular kind of spatial science enquiry which though geared towards deep spatial analysis of GI data is restrictive in its scope for studying place from a more qualitative standpoint. The discussion on pupils' interpretations of place through Google Earth revealed the greater emphasis on visualising locations through this kind of GIS medium. Google Earth holds very little of the analytical capacity of more conventional GIS. The discussion on pupils' interpretations

through hybrid GIS revealed that combining ArcGIS with Google Earth can combine the scientific rigour of more conventional GIS with the often more user-friendly and geo-visual capacities of Google Earth.

## 7.6 Conclusions

The question that arises for geography educators is how best to use GIS to support teaching and learning about place. We can conclude from the discussion in this chapter that GIS can be used to develop relational understanding about place (Harvey [1997] suggests some important ways forward, integrating a systems and a more holistic approach in our study of place through GIS. As the map of geography knowledge construction in hybrid GIS (Figure 7.1) illustrates, this would be a seemly way forward towards teachers working with the strengths of more conventional GIS analysis and the geovisual capacities of newer geotechnologies.

The following concluding chapter considers these thoughts further. The study thus far has been to identify the ways in which GIS can be operationalised to support relational understanding about place in school geography. The map (Figure 7.2) has been used to summarise the key elements of these findings. The map has quite limited application in the specific study of relational knowledge about place without considering some very important questions further. Based on the discussion presented in this chapter, the next chapter presents a model of geography knowledge construction in GIS. I then consider a number of scenarios within which the model could be applied in school geography. I also propose a number of significant questions with regards to the model including: *What use could the model be for teachers using GIS? Does it deliver a clear synoptic message about the role of GIS in constructing place knowledge? What are the both specific and broader educational implications of approaching the use of GIS in geography education in this way?*

I develop this mode of thought in Chapter 8 and in the course of that chapter make a number of recommendations as to how this research and the use of the model could be taken further.

## Chapter 8 Conclusions

### 8.1 Introduction

Chapter 7 presented a synthesis of the conceptual and empirical findings of the research. In response to the research questions identified, it drew together key outcomes from the research and discussed these in the light of the significant literature on the representation of place, relational thinking and the role of GIS in school geography. The associated discussion supported Harvey's (1997) claim that integrating a system and a holistic approach to constructing geographical knowledge in GIS can support better relational understanding of place. There is a need for further discussion of the potential usefulness of this approach to using GIS in school geography if such a claim is to be further substantiated. To achieve this end, this chapter addresses more specifically how a model could act as a framework to guide teachers in the use of GIS in school geography education (Figure 8.1). For the teacher, or geography educator, the model is an invitation to understand how knowledge is constructed through GIS and to critically consider: how does the structure and purpose of GIS influence how geographical knowledge can be made? In what ways, if at all, are the resulting knowledge constructions influential in affecting pupil interpretations of place? And with regards to the broader implications for teaching and learning geography through GIS, what aspects of using GIS could need less emphasis, and which need more?

Before moving on to address the usefulness of the model, I present a synoptic review of the thesis taking into account its main course and arguments. The final section includes implications for further study and improvements that I would make if I were to repeat the study.

### 8.2 Synoptic review

This research was borne out of my initial curiosity about the nature of place knowledge construction through GIS. As a geography teacher and educator I have always been passionate about the importance of the concept of place in geography education. I explored the role of GIS in school



geography and whilst I had noted its benefits for combining geographical information and analysing spatial patterns, I had some concerns about what I had then begun to perceive could be its limited capacity for teaching and learning about place. My reading of the literature on the use of GIS in school education led to me gain greater understanding of the benefits of using GIS in *'learning to think spatially'* (National Research Council, 2006; Sinton and Bednarz, 2007). At the same time, my own research experiences of using GIS in schools (Fargher 2004, 2006) added to my growing sense that although GIS could be used to visualise and analyse spatial patterns and processes effectively, it also appeared to constrain representation and interpretation of place. My further reading of the literature on representation further raised my awareness of matters such as 'narrowed geographical epistemologies' in GIS (Schuurman, 2004) and the implications of limited opportunities for interpreting place (Agarwal, 2004)

As chapter 3 indicated, in deciding to carry out the research, I began by formulating rudimentary questions about the core relationship of the thesis: the connections between the spatial structures of GIS and constructions and interpretations of place. My focus sharpened on the nature of relationality of GIS as an integrating technology and geography as a synthesising body of knowledge (Johnston and Sidaway, 1979). I began to explore and construct a qualitative methodology that would enable me to address issues of GIS practice, teachers' place knowledge construction and pupils' interpretation of place. My identification of the key conceptual themes of: *geographical integration in GIS; place knowledge construction and GIS pedagogy* in the literature on GIS in school geography education steered me towards 'thick description' of teaching and learning processes about relational place knowledge construction in GIS.

Chapter 4 showed that teachers in the Spatially Speaking project shared Sinton and Bednarz's (2007) view that GIS can be an important learning environment for pupils exploring 'geographical issues through spatial relationships' and the benefits that could be associated with 'visualising the spatial' (Schuurman, 2004). Evidence was also discussed in chapters 4, 5 and 6 which highlighted the valuable use of GIS in mapping locational knowledge and using configurational GIS processes to relate geographical data sets (Mark, 1993).

Most pupils using ArcGIS in the *Mapping the land* and *Constructing the tsunami* stages of the research demonstrated their abilities to use GIS to explore, link and analyse important geographical information and to use evidence from their data to demonstrate their wider and deeper geographical understanding. In the main, this involved teaching and learning through the well-established route of 'GIS enquiry' (ESRI, 2005).

The empirical findings reported on in chapters 4, 5 and 6 largely support Harvey's (1996) argument that place can be defined as a '*site of relations between attributes*' and that the idea of any kind of '*independent spatial science*' cannot exist in geography. However the evidence also showed that place knowledge and understanding can be enhanced by opening up geographical enquiry on place through GIS.

At the same time, Chapters 4, 5 and 6 indicated that teaching and learning through ArcGIS (which I have defined throughout this thesis as a more conventional GIS) tended to take the form of a smaller range of pedagogical activity which though highly fit for purpose could be interpreted as being largely dominated by closed GIS enquiry. As the previous statement suggests, this is not to say that this kind of enquiry-based learning was not productive, but evidence also indicated that as a result of the narrow choices provided by conventional GIS, pupils' interpretations were limited to what could be compared to Soja's '*Firstspace epistemologies*' (Soja, 1996). Because GIS enquiry can become dominated by a rather closed cycle of enquiry learning, it resulted in place knowledge being 'fitted into' procedures rather than providing opportunity for extended more open-ended learning about place.

Though highly efficient, speedy and well-suited to gathering, processing and displaying large amounts of digital geographical information, this could lead to rather deterministic and formulaic learning unless the class teacher is aware of these limitations and is prepared to supplement these types of methods with more open-ended learning about place. Similarly, evidence presented in Chapters 4 and 5 suggests that conventional GIS used in schools can still be firmly fixed in a philosophy where a more open, poststructuralist interpretation of place is difficult to achieve (Pickles, 1995; Sui, 2004), mainly because of the more objective view that underlay the ArcGIS technology used in the research. It is important to consider the latter further. It is possible, as the literature on school use of GIS indicates (see in particular Milson, Demirci and Kerski, 2012) that the GIS enquiry

approach that tends to dominate is partially the victim of its own success. The method is tried and tested and can lead to a narrower type of learning than its advocates might first have intended (Fargher, 2013). For example, evidence presented in Chapter 5 showed that despite the 'GIS expert status' of the geography department and the high level of competence in pupil's GIS use at School A it is difficult, to disagree with Soja's (1996) conclusion that this kind of use of conventional GIS can close down potential for other kinds of geographical learning about place beyond: 'human spatiality seen primarily as outcome or product.' (Soja, 1996, p 76).

This type of very structured enquiry-learning was also reminiscent of the critique of maps that is Massey's interpretation of maps as an 'ordering representation' where the: 'map works in the manner of the synchronies of the structuralists. It tells of using cartography to impose an 'order of things' (Massey, 2005, p 106). In 'World City' (Massey, 2006) she argues even more specifically about the challenges of representing place fully through maps, claiming that 'places are crucial.....maybe places do not lend themselves to having lines drawn around them.' (Massey, 2006, p18) in ways that I consider that the proposal of using hybrid GIS in school geography could counter. Though at its early stages in development, the evidence of using this kind of approach that was presented in Chapter 6 further supports the claim that more 'map-deep' use of GIS in school geography can and needs to be explored (Bodenheimer et al; 2010). This type of learning about place through GIS could develop learning beyond 'Firstspace' (the kind of spaces of spatial science that Soja, (1996) described).

More holistic types of geographical information systems in schools can encourage a broader geographical understanding which both utilizes the analytical power of conventional GIS alongside virtual globes. Evidence was presented in Chapters 6 which showed the key role of virtual globes and hybrid GIS in contributing to more open-ended interpretation of space and place in line with Doel's (1999) claim to 'let space take place' (Doel, 1999, p9).

Chapter 7 discussed the conceptual and empirical findings of the research together. It clearly identified the role of GIS in supporting the construction of relational knowledge in school geography. In particular, it considered its influence on teachers' practice and pupils' interpretations of place. The discussion on teachers' practice with GIS revealed that GIS has an important role to play in visualising spatial phenomena, making spatial correlations, 'earth viewing' and supporting enquiry-based learning in school geography. Alongside these important

elements of influence, the discussion also established that GIS can also provide considerable technological and pedagogical challenges for teachers.

In summary, the discussion on ArcGIS revealed that place interpretation through conventional GIS is dominated by a very particular kind of spatial science enquiry which though geared towards deep spatial analysis of GI data is restrictive in its scope for studying place from a more qualitative standpoint. The key question that arose in Chapter 7 was how best to use GIS to support teaching and learning about place. The discussion there identified important ways forward which in integrating a systems and a more holistic approach in our study of place through GIS. As the model presented in the next section indicates, the key element involved in such an approach could be for teachers to work with the strengths of more conventional GIS analysis alongside the geobrowsing and geovisual capacities of newer geotechnologies such as Google Earth.

### 8.3 Modelling geography knowledge construction in GIS

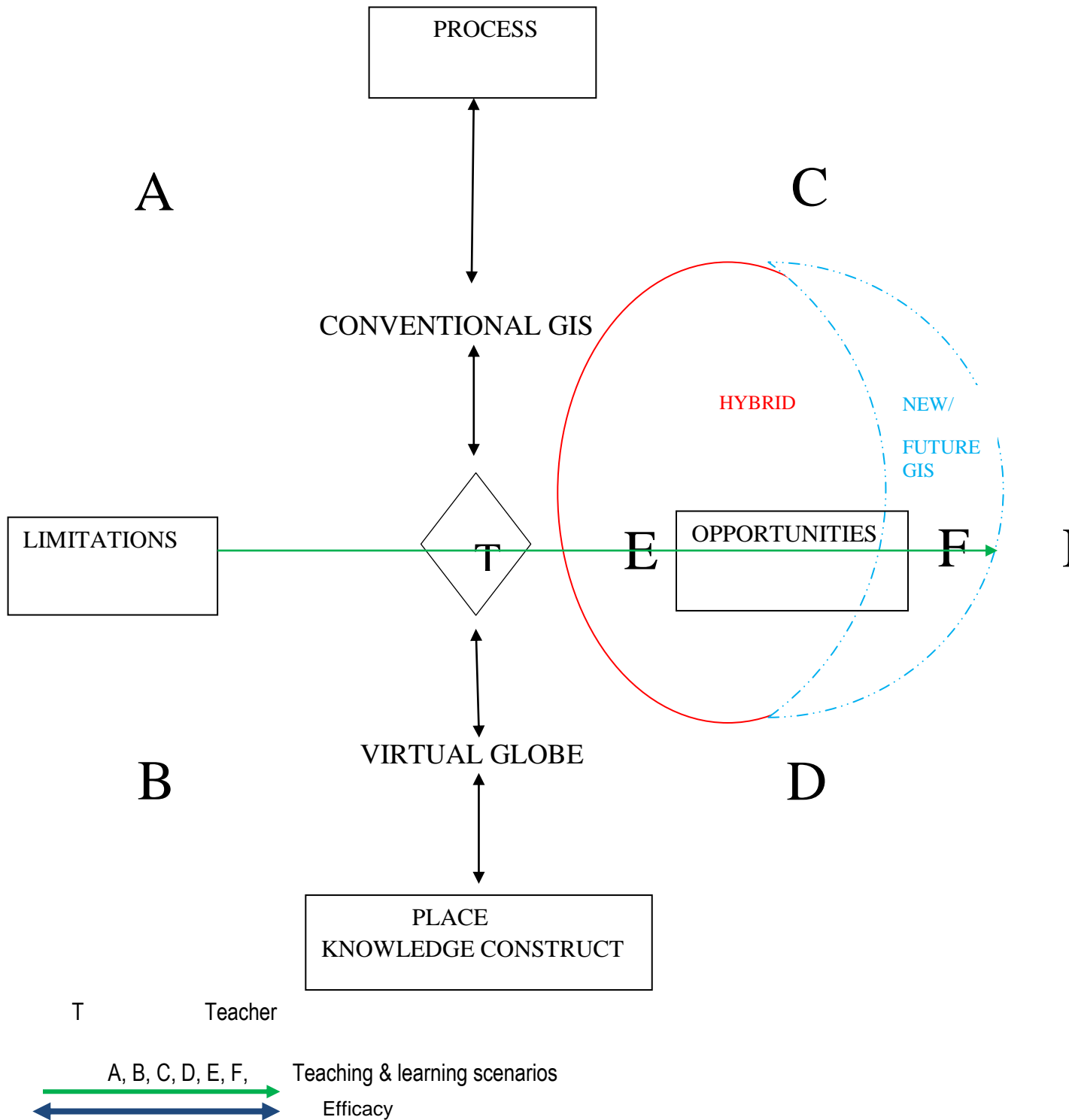
Figure 8.1 outlines a model of constructing geographical knowledge in GIS. It illustrates the significance of the relationship between technological and/or pedagogical process and geography knowledge construction in GIS. Efficacy is also illustrated in the form of a simple continuum which ranges from limitations to opportunities for teaching and learning. The model is designed as a starting point to support teachers' use of GIS in geography knowledge construction.

The model is a prototype and is not meant to be viewed as an end product. It has been formulated in part from the literature review and in part from the evidence presented in this thesis from the empirical work on teachers and pupils constructing knowledge through GIS. It is therefore of educational interest because it may serve as a framework that may be used by both geography teachers using GIS in their teaching and geography educators in teacher education about GIS. As the map of geography knowledge construction in hybrid GIS (Figure 7.1) illustrated, this more critical approach to using GIS is a positive step forward towards teachers working with the strengths of more conventional GIS analysis and the geovisual capacities of newer geotechnologies. By being better versed on the strengths and weaknesses of GIS in

relating digital geographical information, teachers using the model could be better versed in selecting pedagogical strategies supported by GIS in school geography.

The model requires some introductory explanation before discussing the specific implications of its use in school geography and it is to the discussion of those main components that this discussion now turns.

**Figure 8.1** A model of teaching and learning geography through GIS



Point T in the model indicates the initial viewpoint from which a teacher could consider using the model. The sectors (A-F) represent six main 'scenarios for teaching and learning that a teacher could 'view' from their central perspective in the model. Each sector is characterised by particular

types of teaching and learning through GIS as borne out by the findings of the research (Sector F is the exception as this models 'new/future GIS').

- In scenario A the limitations of conventional GIS outweigh the opportunities for teaching and learning
- In scenario B the limitations of a virtual globe outweigh opportunities for teaching and learning
- In scenario C the opportunities provided by conventional GIS outweigh the limitations for teaching and learning
- In scenario D the opportunities provided by a virtual globe outweigh the limitations for teaching and learning
- In scenario E the opportunities provided by conventional GIS and a virtual globe are combined in hybrid GIS
- Scenario F represents the likely opportunities provided by 'new/future GIS' for teaching and learning

In the next section I discuss the significance of this research and the implications and considerations of each of the model's illustrated scenarios of using GIS in schools for geography teachers and geography educators.

#### 8.4 Using the model

Sector A is characterised by teaching and learning which could though centred on the advantages of spatial analysis in GIS, be limited by conventional GIS processes to a narrow range of methods. The 'geographical teaching spaces' created in this more conventional GIS opens up a world within which pupils construct and interact with knowledge within the strict confines closed enquiry but where this knowledge is rarely developed beyond this point. Pupils are able to make connections between locations, to define, manipulate and read 'abstract GIS space' and to reach simple conclusions based mainly on prescribed and limited enquiry learning. Teaching and learning geography through this kind of approach can often be repetitive and formulaic.

Sector B is characterised by teaching and learning which though centred on the advantages of geobrowsing and 'earth viewing' in a virtual globe, the 'geographical teaching spaces' created in this less technical GIS opens up a world within which pupils construct and interact with place knowledge based on visualising locations and geographical phenomena through satellite imagery and photography, but rarely moves beyond this point. 'GIS- assisted school geography education' as represented by Sector B is based on using volunteered geographical information which though often engaging and illuminating is restricted to data that can be visualised and is almost entirely devoid of the spatial analytical capacity in a 'true GIS sense'.

Sector C is characterised by teaching and learning which focuses on a wide range of spatial analyses in GIS. The 'geographical teaching spaces' created in this more conventional GIS capitalises on its huge mapping and analytical capacity. Pupils learn to 'think spatially, synthesise geographical information and process and visualise large amounts of geo-referenced data quickly and iteratively (Sinton and Bednarz, 2007). Both 'Mapping the Land' (Chapter 5) and 'Seismic Gap Theory' (Chapter 6) are good examples of using conventional GIS in this way.

Sector D is characterised by teaching which focuses on the benefits of visualising locations and the 'fly to' capacity of virtual globes. The 'geographical teaching spaces' created in this more alternative GIS capitalises on the strengths of modern geovisualisation and opens up a world where pupils can place themselves in virtual digital locations, 'annotate the planet' (Udell, 2005) and interact with a range of heterogeneous geographical information. 'Earthquake and tsunami impacts' (section 6.3.7) is a good example of using a virtual globe in this way.

Sector E is characterised by teaching and learning which combines the benefits of both conventional GIS and a virtual globe in a hybrid GIS. This research supports the claim that hybrid GIS can combine the scientific rigour of more conventional GIS with more open concepts of place and high quality visualisation, particularly with regards to satellite imagery. The essential characteristic of this approach is the combination of the analytical systems approach in ArcGIS and the more open-ended use of the Google Earth viewer reminiscent of Harvey's holistic/systems approach to thinking geographically through GIS (Harvey, 1997). 'After the tsunami' (section 6.3.10) is a good example of combining conventional GIS with a virtual globe in this way.



Sector F is hypothetical but is illustrated in the adapted model to illustrate the position of new/future GIS.' At the time of writing GIS has begun to move online in the form of virtual mapping platforms which will ultimately eradicate the need for physical GIS software. The 'geographical teaching spaces' created in this new/future GIS can already combine web-based maps and visualisations in a much easier to use format although this new GIS is only in its early stages of use in schools. New online GIS accommodate solely cloud-based data with the capacity to stream more dynamic geographical data. 'Future GIS' (albeit only in beta form at present) already displays the potential for streaming live, dynamic 'real time GIS' mapping, satellite and photographic geovisualisation (ESRI, 2013). There is considerable scope for further related research with regards to 'Future GIS' and school geography education in this regard.

## 8.5 Evaluation and recommendations for further research

In the opening paragraph of this thesis I referred to the erudition of Cresswell's (2004) view on place 'as a rich and complicated interplay of people and the environment.' I stated there that relational understanding of place (in the way that Cresswell implies) is a fundamental aspect of geography education. In her broader discussion on the social construction of space, Massey (2005) argued for a more open-ended interpretation of relationality:

Space can never that completed simultaneity in which all interconnections have been established, and in which everywhere is already linked with everywhere else. A space, then, which is neither a container for always- already constituted identities nor a completed closure of holism. This is a space of loose ends and missing links. For the future to be open, space must be open, too.

(Massey, 2005, p 11)

My main aim for the thesis was to explore the role of GIS in operationalizing this key element of geography, to examine closely its synthesising processes and to investigate the educational implications of these for constructing and interpreting relational place knowledge in school geography. The research findings have supported other research on GIS use in school geography education that identifies its' considerable scope for developing young peoples' spatial literacy. In

particular, the research builds on other findings by exemplifying how GIS has a specific role in geography education as an important connecting medium where relational geographical knowledge and understanding can be contextualised. However, the research has also shown that GIS can limit both representation and conceptualisation of place.

Findings have also indicated that where teachers adopt more critical approaches, GIS can be used to better support relational interpretations of place, particularly through hybrid GIS. With regards to constructing place knowledge in GIS, I have also come to realize that concentrating only on the objective versus subjective nature of place knowledge generated through GIS versus subjective interpretations of place is not the only point of relevance to emerge from the classroom research. Rather, it is the focus on generating questions about the construction of knowledge about place in the classroom (in this research, albeit through GIS) that has been most productive. I am not arguing here that all of these are possible or desirable within GIS in geography education, but I am presenting the argument that teachers need to be critical of their use of GIS to house, present and analyse knowledge with students.

What is crucial is the contribution of teachers as critical users of GIS. My thesis argues for more innovative approaches to using GIS, whereby teachers construct broader and richer ranges of digital geographical knowledge about place, through more critical use of more conventional GIS and newer geo-technologies and by considering the potential of hybrid GIS. Though the latter was not fully developed through this research, it is an approach which could be a very fruitful avenue of future research in the field based on the implications of this thesis. In particular, by building on the basic structure of GIS use in schools, further research could provide (as Harvey discusses, 1997), more holistic types of geographical information systems in schools. I argue that this approach can encourage a richer development of geographical interpretation of place which utilizes the analytical power of conventional GIS and the neogeographical applications available in virtual globes. The model of geography knowledge construction through GIS (Figure 8.1 goes some significant way to formalising the findings of the research in ways that could be of use to both geography teachers and educators although it could have taken into account the role of pupils in the process more closely. It is also important to reflect more critically in this penultimate section on the completed research project as a whole and particularly the relative successes or possible suggestions for improvements with regards to the methods of data collection and analyses. With regards to the research project as a whole, my discussion of the complexity of the research design (see Chapter 3, p\_) revealed both the

logistical challenges associated with conducting three separate empirical enquiries and the subsequent complexity of reporting on each of these individually and then synthesising and analysing their findings in order to reach viable research conclusions. As stated in my discussion on research design and my thinking behind using three different research settings, whilst this approach could be interpreted as long-winded, there was always a commitment to seeking out 'thick description' of teacher practice and pupil learning through GIS. In hindsight, methods employed in each of the three empirical studies could have been improved. For example, with regards to the *Spatially Speaking* case, whilst I collected a rich array of data on teacher practice, in retrospect, my focus at the time could be interpreted as concentrating mainly on the more general influences of GIS on teaching and learning and not as specifically on place per se.

On the other hand, I am of the opinion that the secondary analysis of the original *Spatially Speaking* data went some way to compensate on this perceived limitation. The analysis went a considerable way to illuminating the ways in which GIS influences teacher practice particularly with regards to its role in facilitating integration of geographical data sets, supporting robust pedagogy in the form of geographical enquiry and enhancing geovisualisation methods. As Long-Sutehall et al (2010) and Hinds et al; (1997) also argue, secondary analysis can provide potential for the researcher to look at their data with fresh eyes and reveal data trends that may not have been quite as transparent during the primary analysis. I would most certainly consider using secondary analysis in future research, particularly where I could combine the use of research analysis software such as the Xsight programme used in the primary study (Fargher, 2006) alongside manual comparison coding. Also with regards to the collection of the *Spatially Speaking* data, I did not take full advantage of opportunities that arose to collect and analyse pupil data that could have been used to further triangulate findings in this research.

With regards to the *Mapping the Land* case, there is also an argument to be made for my under-use of pupil interviews in the data collection. Whilst the non-participatory lesson observations allowed for rich description of teaching and learning processes in the classroom, in retrospect, fuller interaction through pupil interviews could have added further perspective on answering my second research question : *How does GIS influence how pupils interpret place?* On the other hand, it can also be concluded that the 'progressive focussing' (Stake, 1991) that underpinned the research methods helped me to address this question more directly in the *Constructing the tsunami* practitioner research study.

## 8.6 Concluding Comments

In these final concluding comments, it is useful to drawback from these specific conclusions and re-consider some of the 'bigger picture issues' about using GIS to support geography education in schools.

First is to raise the question of the broader educational implications here, including how, we engage young people *geographically* in school education. This question instantly reminds me of Peter Jackson's first discussions about the significance of the 'language of geography' (1989). I would argue that the fluency that Jackson implies when he discusses geography's key vocabulary and its grammar is a very long way from being a given if we are to embrace more meaningful use of GIS in schools. If there is to be a way forward with using GIS to support geography education there is a need to focus on the *grammar of GIS* in ways which are *more* accessible and not as cumbersome as they currently remain in a GIS-assisted curriculum based largely with US-based geographical science curricula using GIS systems which have not inherently changed over the last two decade. Key geographical concepts such as a broader interpretation of space and place need to be part of this conversation.

Second, is to be at least healthily cautious of the (at least partial) myth that newly-emerging GIS are 'different' to conventional GIS and offer more opportunities for supporting geography teaching and learning in schools. We need to remember that they have none of the analytic modelling, and inferential power of GIS, and while oriented to visualisation are nevertheless very limited in what can be visualised, *because of their insistence on content that is inherently visual*. That is not to acknowledge the potential of using this kind of geo-visualisation. It is true that the visual impacts on geography students of geobrowsers go well beyond those of GIS, reaching (with careful stewardship) into a broad and rich domain of spatial concepts' that can be very powerful aids to both geographical understanding and insight.

Third, is the role that geography education in both its formal and informal guises has to play in wider society. The findings from the research also support the notion that newly-emerging, more user-friendly GIS have an important part to play in a vibrant and meaningful 21st century education. At the same time, it is important to acknowledge that there is still a need to be critical of the way in which knowledge through such technologies is constructed. In particular, knowledge about place

constructed through a richer more meaningful geography education is not to be confined to a scientific view. In his broader and much earlier critique of the knowledge economy, Lyotard discusses the overriding educational significance of this kind of representation of knowledge:

Along with hegemony of computers comes a certain logic, and therefore a certain set of prescriptions determining which statements are accepted as 'knowledge statements' (Lyotard, 2004 p4)

The recognition of the need to be critical of knowledge constructed through GIS does not change the potential uses of GIS in supporting geography education but it does change the emphasis on what and how place can be understood through GIS. In particular, it heightens the significance also of the teacher's role in using GIS to construct geography knowledge but also about the role of using technologies such as GIS to help young people frame their development of geographical knowledge and understanding – using the technology and practice to enable them further to use geography's key concepts in understanding the world around them.

For example, to return to an issue already raised in this research, at a time when climate change is at the top of many agendas some advocates of GIS and virtual globes are beginning to actively promote 'climate literacy for the twenty-first century'[23]. However, the same arguments focussed on positivism, ethics and hidden agendas that earlier commentators raised about GIS in particular need to be considered when considering the use of GIS 2.0 as it becomes increasingly ubiquitous in our everyday lives. Particularly in terms of the contribution to 'public geographies' and participatory and volunteered geographical information. But also, the social complexity and dynamism of geographic knowledge in the digital age. But significantly, also is the argument put forward by e.g. F.Harvey (2007) re: the move towards post-modern 'ubiquitous computing –based geographic communication.' (Harvey, 2007, pg.\_\_, AAG, 2007). Geography education in schools with GIS has an important moral role to play in supporting critical use of this kind of geo-technology.

Finally, what I am ultimately arguing for here is more critical approaches to using hybrid forms of GIS, whereby all users are able to engage authentically with what can be an incredibly enabling range of technologies. In particular, by building on the basic structure of GIS use in schools, this could provide (as Harvey discusses, 1997), more holistic types of geographical information systems in schools. I argue that this approach (as the tsunami lessons suggest) encourage a richer development

of geographical imaginations which both utilizes the analytical power of traditional GIS but also the public geographies' ; VGI; neogeography elements and geovisualisation of virtual globes and other new geotechnologies.

In his speech 'Digital Earth: Understanding our planet in the 21<sup>st</sup> Century,' Gore encouraged us to imagine what this might involve:

Imagine for example, a young child going to a Digital Earth exhibit at a local museum. After donning a head-mounted display, she sees Earth as it appears from space. Using a data glove, she zooms in, using higher and higher levels of resolution, to see continents, then regions, countries, cities, and finally individual houses, trees, and other natural and (hu)man-made objects. Having found an area of the planet she is interested in exploring, she takes the equivalent of a 'magic carpet ride' through a 3-D visualization of the terrain.(Gore, 1998)

According to Gore, Digital Earth would allow us to 'capture' vast amounts of digital information about our planet. Although his speech did not quite herald the new era of geographical knowledge that its rhetoric suggested it partially predicted the significance of geotechnology (GT) and its potential influence on our geographical imaginations. In the subsequent decade we have indeed become increasingly familiar with, if not 'Digital Earth' at least online virtual globes such as Google Earth. I agree with current debates that suggest that virtual globes have much to offer in promoting geographical understanding. However, I also believe that the same arguments focussed on positivism, ethics and hidden agendas that earlier commentators raised about GIS in particular need to be considered when considering the use of virtual globes in geography education. In connection with this the hegemonies associated with commercial virtual globes need careful consideration.

If relational thinking is a many of us believe, (Massey, 2005; Murdoch, 2006,) both significant and relevant within this type of 21<sup>st</sup> century geography education, this implies, then we need to think carefully about the frameworks for thinking we create – the type of knowledge that we legitimize - and the type of geographic information systems that we engage with pedagogically in our schools. In particular, more critical use of GIS in schools challenges the epistemological frameworks within which commercial GIS is usually designed. The mass digitization of data has actually made our need to be conscious and critical of the language and meanings *behind* the signs and symbols present in GIS. As with any semiotic medium, it is important to be aware of the different discourses which are being represented within it. GIS the commercial product comes straight from realist and pragmatic origins,

and is often constructed or used to predict events and to problem-solve. Appropriate for some types of student enquiry some might argue, but surely worthy of more careful consideration if education is to include ways of thinking about places with GIS in broader and richer ways than these. As Elwood (2006) argues:

GIS is tremendously important because it is such a powerful mediator of spatial knowledge, social and political power, and intellectual practice in geography. in short, the answer is the same as it was ten years ago : Because the stakes are high.

(Elwood, 2006, p 693)

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## Appendices

A1 Interviews



## i. Teacher Interviews

Names used for Teachers featured in interviews this thesis

The following fictionalised names have been used to indicate teachers involved in the research. I have placed each teacher in a broad category according to their GIS experience.

David Experienced

Eleanor Some Experience

Jenny Inexperienced

John Experienced

Julie Inexperienced

Marco Inexperienced

Mike Experienced

Sandra Inexperienced

Simon Experienced

## Li Pupil Interviews

Names used for **Pupils** featured in interviews in this thesis

The following fictionalised names have been used to indicate pupils involved in the research. I have placed them in categories according to their ability group (as allocated at SchoolB).

Aaron Band 1

Brione Band 3

Dan Band 3

David Band 1

Deena Band 2

El iot Band 1

Gabby Band 2

Jamie Band 3

Jason Band 3

Jenna Band 2

Jo Band 1

John Band 1

Mark Band 3

Maya Band 2

Mishra Band 3

Sabrina Band 2

Nicole Band 2

### iii. Interview Questions

#### Teacher Interview Prompts.

1. Making reference to any examples you can think of, to what extent do you feel the project and using GIS has enabled your pupils to :

- a. analyse geographical data more effectively?
- b. Use this GIS generated data to more successfully debate and argue points of view orally and/or in writing?
- c. Use this GIS generated data to make problem solving decisions?

2. To what extent do you think your involvement in the project has challenged your understanding of how to develop pupils' spatial literacy?

3. To what extent has your involvement in the project extended your pupil's abilities to:

- a. Debate and argue points of view orally and/or in writing?
- b. make problem solving decisions?

4) To what extent do you think your involvement in the project has challenged your understanding of developing pupils' spatial awareness?

5) To what extent do you feel your involvement in the project has enabled your pupils to 'speak spatially'?

6) Do you have any other comments that you would like to make?

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iv. Pupil Interview - Prompts

How did you identify the countries affected by the tsunami?

How did you identify the countries with the largest death tolls?

How did you identify the main features of the largest earthquake that occurred on Boxing Day?

How did you study the changes over time?

How did you find out the range of earthquake size?

How did you work out when the earthquakes occurred?

How did you study the pattern of earthquake change over the six days?

How did you study the tsunami waves?

Where did most of the earthquakes occur?

In which direction did most of the epicentres occur?

What were the main similarities and differences between the earthquake activity between 26/12 and 31/12 and the period between 26/12 and 31/05?

Where were most of the earthquakes which occurred between 31/5 and 11/5/05?

What did you notice about the three earthquake time periods that were different?

What were the differences before and after in the villages?

How did you use seismic gap theory?

How did you use GE to find locations?

What did you find?....

What else did you do ? .....

Measure distances?

Placemarks?

What else did you do ?

Did you look further?

UK? Kamboja case study?

Around the world?

Video?

---

A2 Observations

i.Lesson Observation Prompts

1. How is the classroom teacher organising their teaching with GIS?
2. Which procedures are pupils using when working with GIS?
3. How is place knowledge constructed through GIS in this lesson?

**DECLARATIVE KNOWLEDGE**

PLACE (NAMES), LOCATION, SPACES, DISTANCE, SCALE, VOCABULARIES ABOUT PLACE

**PROCEDURAL KNOWLEDGE**

GIS NAVIGATIONAL SKILLS

- Orientate
- Pan
- Zoom
- Link
- Co-ordinate
- GPS

**CONFIGURATIONAL KNOWLEDGE**

RECOGNISING & INTERPRETING

GEOGRAPHICAL PATTERNS

MAPPING GEOGRAPHICAL PATTERNS

- Display/Annotate/placemark
- Measure
- Attribute
- Tabulate

- Overlay
- Input
- Edit
- Symbolize
- Aggregate
- Classify

#### ANALYSIS

- Query

4. To what extent is relational construction of knowledge about place evident in this lesson?





### A3 Classroom Documents

## A.Mapping the Land - Pupil Guidance

## GIS GCSE Fieldwork Case Study – What is the Urban Structure of Bishop's Stortford and does it fit the models of Burgess and Hoyt?

### 1. Why GIS?

GIS is fundamental to geographical education as it is the most powerful medium through which the analysis of spatial information can currently take place. In this regard GIS can be an invaluable resource for extending pupil learning through fieldwork, data analysis and spatial reasoning concepts. Unlike paper mapping activities GIS allows students to more quickly map where things occur and advance to the more important and inter-related question of why things occur. In essence GIS is a powerful tool for enhancing the role of thinking in geographical learning and fieldwork.

### 2. GCSE Coursework, Data Processing and Analysis Using GIS

Over the last four years GCSE students at Bishop's Stortford College have been using GIS to help complete their coursework. Pupils use GIS to help create spatially referenced tables, graphs and maps. The output of GIS use has been found to significantly aid the quality of pupils' data presentation and analysis at all ability levels. Pupils have successfully completed their project work with no previous experience of GIS use.

About 6 to 8 weeks of class time is given over GCSE project work. Of this time at least 4 weeks will be spent on using the GIS software.

The GIS software used by the College is the ESRI product ArcView 9.0. All the instructions provided in these resources relate to this brand and version of GIS software.

### 3. The Nature of the Coursework

The focus of the coursework is to get pupils to map the housing quality and landuse of Bishop's Stortford. Pupils then use this information to critically assess the models of Burgess and Hoyt.

#### 3.1 Fieldwork Preparation

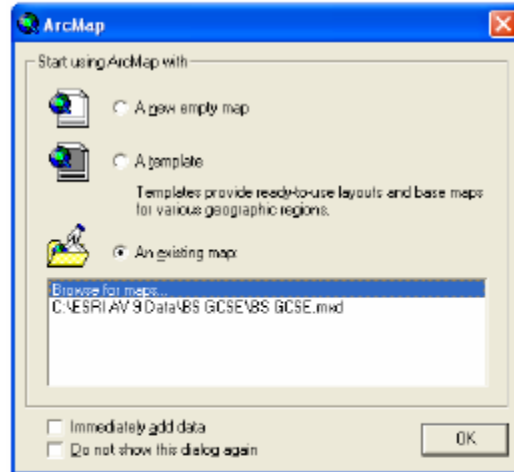
Prior to the fieldwork day pupils are taken through several different stages of preparation by their teachers;

1. Pupils are introduced to the task on Urban Structure and allowed to decide on their title. Most use the idea of comparing structures with Burgess and Hoyt as we have introduced these models earlier in their teaching.

## Part 1: Getting Setup To Start Using Your GIS Software

### Launch ArcMap

1. You will need to create a new folder where you save all your GCSE and GIS project work to. Call this folder **GIS PROJECT**.
2. From the windows taskbar, click **Start, All Programs, Local Applications SS ICT Lab, ArcGIS, ArcMap**.
3. In the resulting ArcMap window, click the **An existing map** radio button and click **OK**.

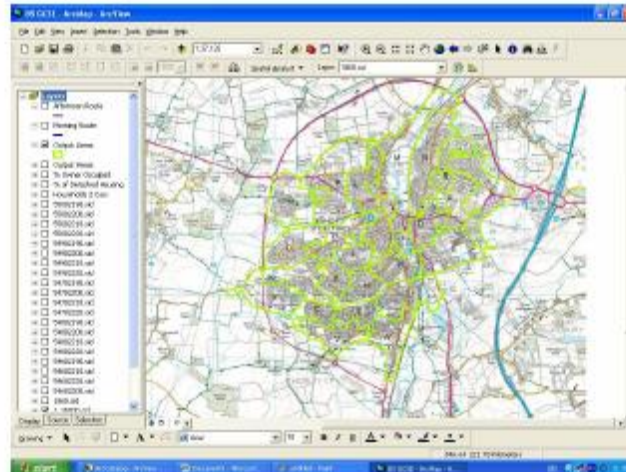


## Open an existing map

1. Browse to the drive on which your GIS GCSE project folder has been installed (e.g. O:\GIS\V9\BS GCSE), click the BS GCSE icon and click **Open**.



The BS GCSE mxd project opens in ArcMap showing all the data you have available to you to complete your GCSE project work



**VERY IMPORTANT:** Once you have opened your GCSE project now save this information to your own drive area (e.g. the new project folder that you have just created). Everything that you now do for this project must be saved to the same folder.

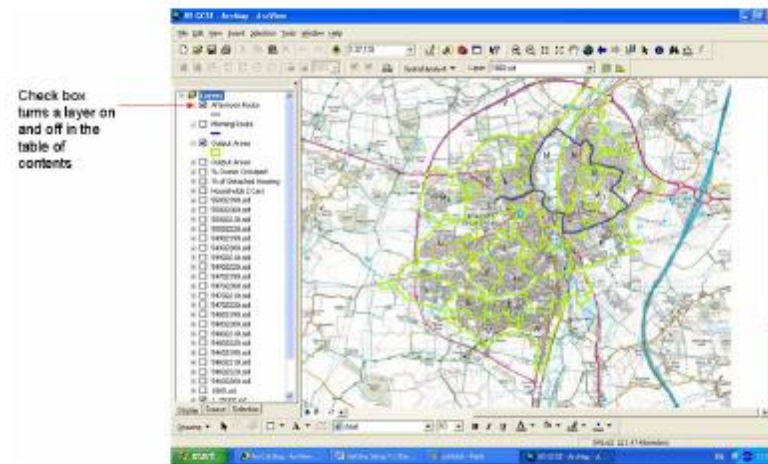
## Map Layers

Map layers are references to data sources such as historical maps, Ordnance survey maps, aerial photography, Census 2001 data that can be displayed in ArcView.

### Turn a Layer ON or OFF

1. Click the small check box to the left of the **Afternoon Route** layer in the table of contents to turn that layer on or off.

The table of contents is the panel on the left side of the view window. If the table of contents accidentally closes, click Window, Table of Contents to reopen it. A check mark appears if the layer is turned on. Nothing appears if it is turned off.



#### Changes a layer's display order

1. In the table of contents, click and hold down the left mouse button on the name of the Afternoon Route layer
2. Drag the Afternoon Route layer down to the bottom of the table of contents

ArcMap draws layers from the bottom up. Because the Afternoon Route layer is now drawn first, its lines are now covered by all the other layers contained in the table of contents.

3. Click and hold down the left mouse button on the Afternoon Route layer.
4. Drag the Afternoon route layer back to the top of the table of contents.

Because the Afternoon Route layer is now drawn last, its points can be seen again

## Zoom and Pan

Zooming and panning enlarges or reduces the display and shifts the display to see different areas of the map. The zoom and pan buttons are found on the Tools toolbar



### Zoom In

1. Click the **Zoom In** button.



2. Click and hold down the mouse button on a point above and to the left of the polygon (Census Area) labelled M.
3. Drag the mouse below and to the right of the polygon labelled E and release the mouse button



4. Click once on the screen to zoom in, centered on the point that you clicked.

This is an alternative to dragging a rectangle for zooming in.



### Fixed Zoom In

1. Click the Fixed Zoom In button



This zooms in a fixed distance on the centre of the current zoomed display

### Zoom Out

1. Click the Zoom Out button



This zooms out a fixed distance from the centre of the current zoomed display.

### Pan

Panning shifts the current display to the left, right, up, or down without changing the current scale.

1. Click the Pan button.



2. Move the cursor anywhere onto the map display
3. Hold down the left mouse button and drag the mouse in any direction
4. Release the mouse button

### Zoom to Full Extent

1. Click the Zoom to Full Extent button.



This zooms to a full display of all layers, regardless of whether they are turned on or turned off.

### **Zoom to the Previous Extent**

1. Click the Zoom to Previous Extent button.



This returns the map display to its previous extent. Continue to click this button to step back through views.

### **Zoom to the Next Extent**

1. Click the Zoom to Next Extent button



This moves forward through the sequence of zoomed extents you have viewed. You can continue to click this button until you reach the most recently viewed extent.

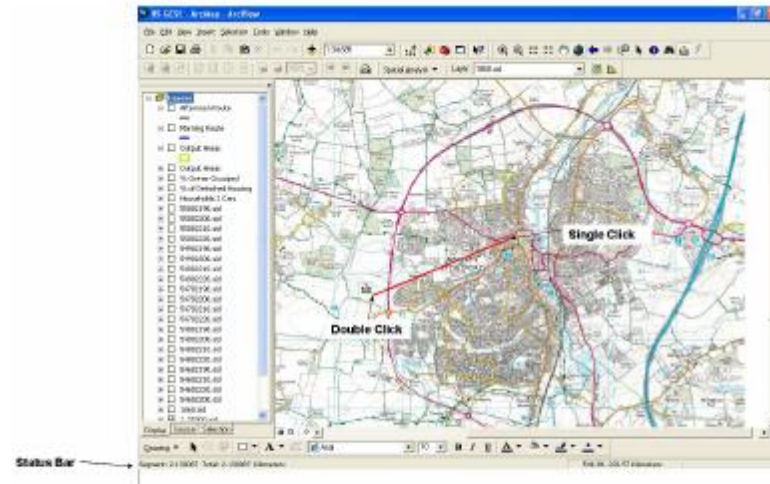
## Measure Distances

Measure the horizontal distance from the centre of Bishop's Stortford to the edge of town.

1. From the Tools toolbar, click the Measure button.



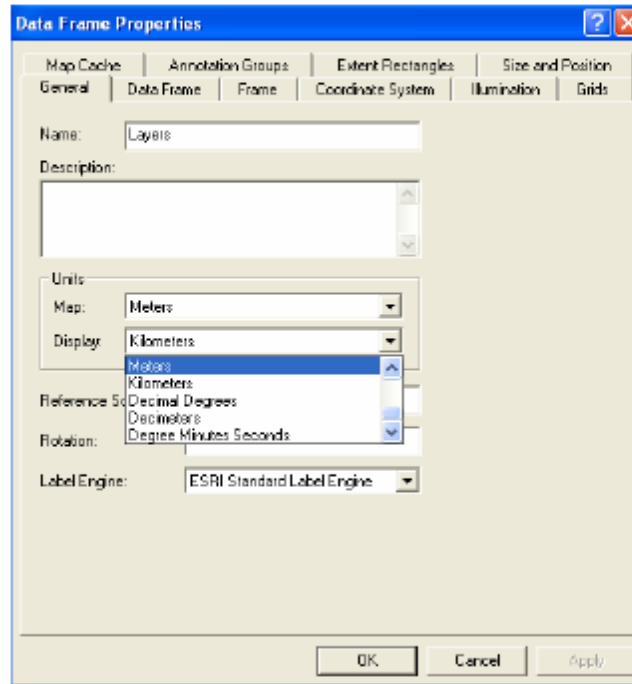
2. Click once on the centre of Bishop's Stortford
3. Drag the mouse to the edge of any part of Bishop's Stortford.



The resulting distance is shown on the status bar found on the lower left corner of the screen. The distances for this layer are shown in kilometres.

### Change Distance Measurements

1. Click View, Data Frame Properties, and the General tab.
2. In the Units frame, change the Display units to meters
3. Click OK.



When your results are how displayed in the status bar the unit of measurement is now meters. This will be a helpful tool in testing if there is any relationship between increasing housing quality and increasing distance from the CBD.

### Identify Features

The identify tool displays the data attributes of a feature by clicking the feature on the map. This tool is the easiest way to learn something about a location in a map.

#### Identify the % of different types of housing in Bishop's Stortford

1. Turn off all layers except % of Detached Housing & 1\_25,000.sid
2. From the Tools toolbar, click the identify button.



3. Click inside any of the polygon areas for Bishop's Stortford

The polygon (Census Area) that you choose will temporarily flash and its attributes appear in the Identify Results dialog box

### Preparing Your Data for Import into Your GIS Project

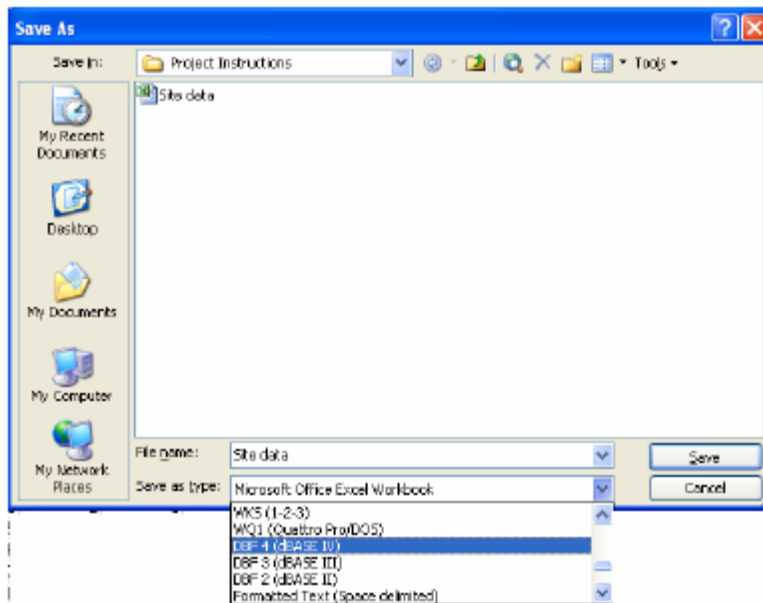
	A	B	C	D	E	F	G	H	I	J
1	Site	polygon	house size	garden size	access	no of windows	maintain	parking	cbd	total
2	1	a	3	1	7	1	3	1	7	23
3	2	a	5	9	3	9	4	9	3	42
4	3	b	4	9	5	9	1	9	5	42
5	4	b	6	4	4	4	9	4	4	35
6	5	c	7	3	6	3	9	3	6	37
7	6	c	5	5	7	5	4	5	7	38
8	7	d	9	4	5	4	3	4	5	34
9	8	d	8	6	9	6	5	6	9	49
10	9	e	3	7	8	7	4	7	8	44
11	10	e	3	5	3	5	6	5	3	30
12	11	f	5	9	3	9	7	9	3	45
13	12	f	5	8	5	8	5	8	5	44
14	13	g	6	3	5	3	9	3	5	34
15	14	g	6	3	6	3	6	3	6	36
16	15	h	7	5	6	5	3	5	6	37
17	16	h	7	5	7	5	3	5	7	39
18	17	i	8	6	7	6	5	6	7	45
19	18	i	8	6	8	6	5	6	8	47
20	19	j	2	7	8	7	6	7	8	45
21	20	j	2	7	2	7	6	7	2	33
22	21	k	3	8	2	8	7	8	2	38
23	22	k	3	8	3	8	7	8	3	40
24	23	l	5	2	3	2	8	2	3	25
25	24	l	5	2	5	2	8	2	5	29
26	25	m	6	3	5	3	2	3	5	27
27	26	m	7	3	6	3	2	3	6	30
28	27	n	8	5	7	5	3	5	7	40
29	28	n	8	5	8	5	3	5	8	40
30	29	o	4	6	6	6	5	6	6	39
31	30	o	9	7	4	7	5	7	4	43
32	31	p	9	8	9	8	6	8	9	57
33	32	p	10	6	9	6	7	6	9	53

1. Once you have collected all your data you need to input this information into EXCEL. In order to be able to join this data later on to your map you will need to ensure that you include your site numbers and identify which polygon each site belongs to. For example site 1 is found in polygon A.
2. It is very important that once you have entered your data into EXCEL that you do not format any of the data. For example, do not change the column widths, make the text bold, add boxes around certain cells etc. If you do this ArcView will not be able to read your data.
3. When you enter you polygon labels make sure that they are in small letters.
4. Make sure that the column with your site numbers is labelled site.
5. Make sure that the column with your polygon letters is labelled polygon
6. Make sure you total up the values for each site

7. When you have finished these tasks make sure your cursor is placed in A1 as shown above.
8. Once you have finished preparing your data it should look like the table above. Save your Excel file to your GIS Project folder and call it Site\_data.
9. Finally copy the contents of the spreadsheet. Open a new empty EXCEL spreadsheet. From the edit menu choose **paste special** and click **values**. Save and call this file site\_data. Make sure your cursor is in A1 when you save the file.

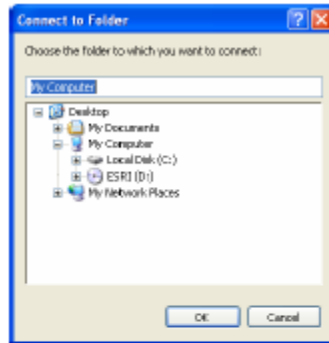
#### Saving your EXCEL data for Import into ArcView

1. ArcView cannot read Microsoft EXCEL workbooks so you have to save your data to another file format.
2. From the File Menu choose Save As.
3. From the Save as type Menu choose DBF (dBASE IV)
4. Make sure you save this file to your GIS project folder.

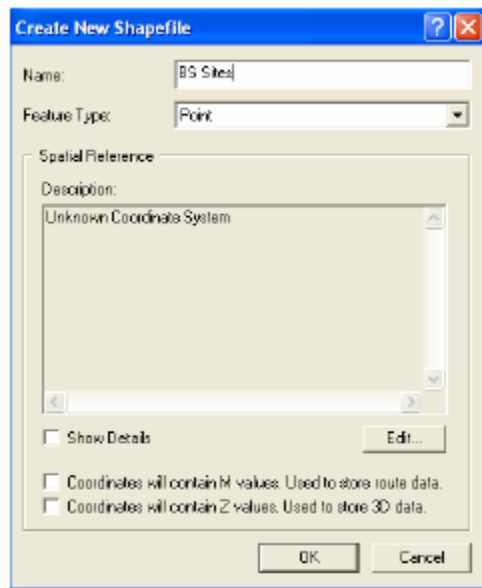








4. Once you have made a connection to your project folder in the catalog tree navigate to \GIS Project\
5. Click **File, New, Shapefile**.
6. In the name field, type **BS\_Sites**
7. From the **Feature Type** drop-down list, choose **Point**.
8. Click **OK**



## Add the BS Sites Shapefile to Your Existing Project

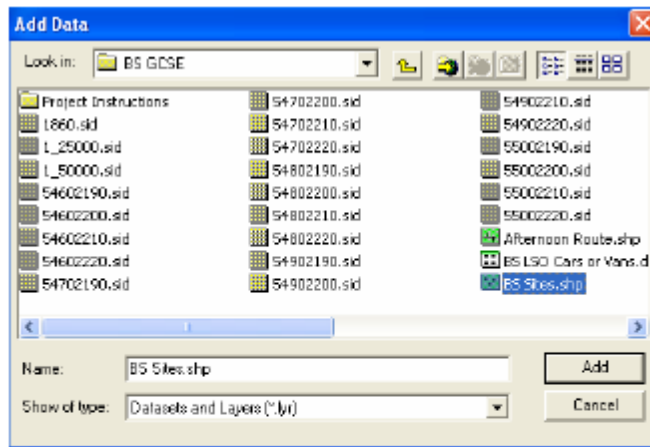
### Launch ArcMap and Open Your GIS project folder map

#### Add a layer

1. Click the Add Data button



2. In the add data browser, browse to your project folder
3. Click BS\_Sites.shp
4. Click Add



5. You will be prompted with a statement saying data from these layers cannot be projected, click OK.
6. Turn on your outline of the polygon areas and the 1\_25000.sid layers. Turn off all other layers. However, you may at times want to turn on other layers like your route to help you better identify the location of your sites.

## Add Site Points

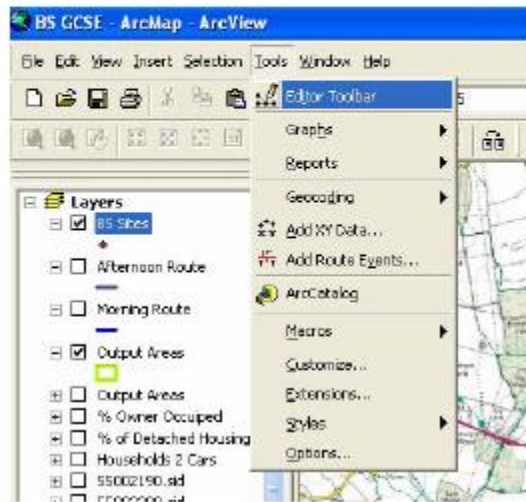
### You are now going to start entering your points on the map

In order to help you join your data in the spreadsheet that you created with the points that you are about to draw it is important to appreciate that ArcMap will label each site in the order that you draw the data. The first site you enter will be recorded as site 1 or 0 by ArcMap. As a result site number 1 in your spreadsheet needs to be the first site you label on your map. The second site that you draw on your map needs to be site number 2 in your spreadsheet.

It will probably be easiest to draw your site data on your map in the order that you collected your data on your fieldwork day.

It will also be helpful to have a copy of your spreadsheet, a map of your site locations and your fieldwork route when you carry out the drawing of your sites digitally.

1. From the Tools Menu click **Editor Toolbar**

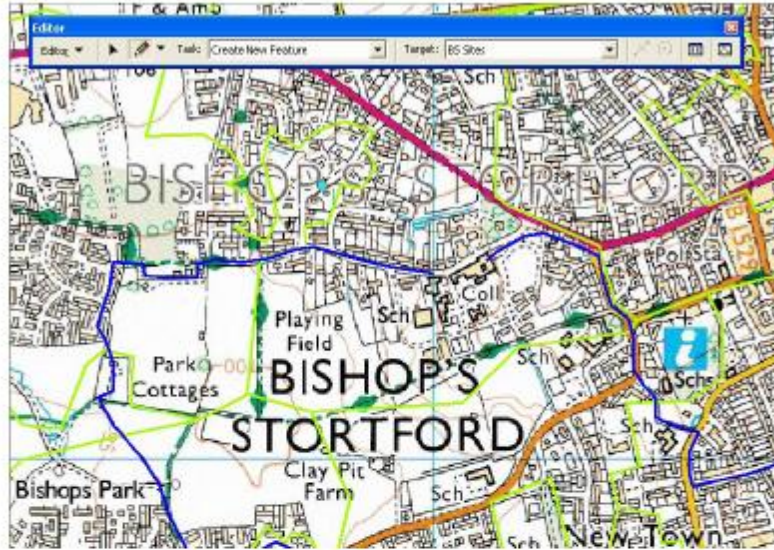


2. From the Editor toolbar, click **Editor, Start Editing**



Be sure the Target layer is BS Sites

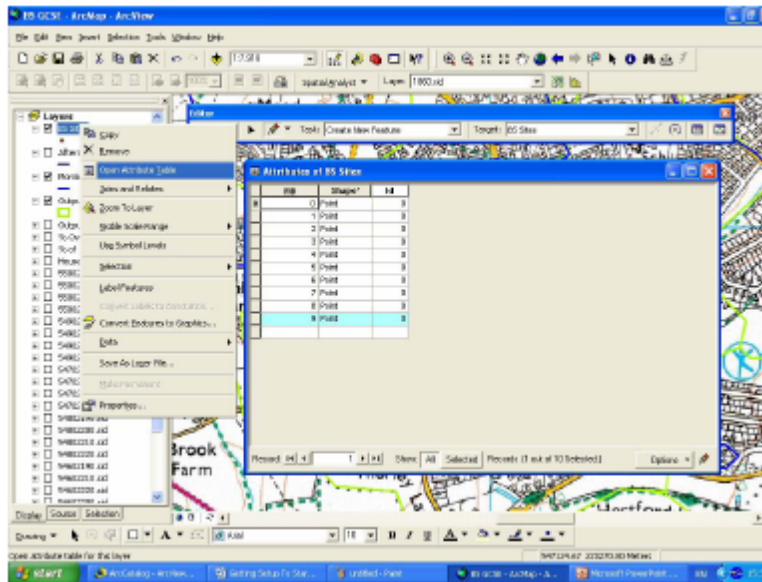
3. Zoom down into the area of a polygon where you want to draw your first sites.  
Also turn on the layer that shows your route through the polygon so that you accurately locate the position of your sites.



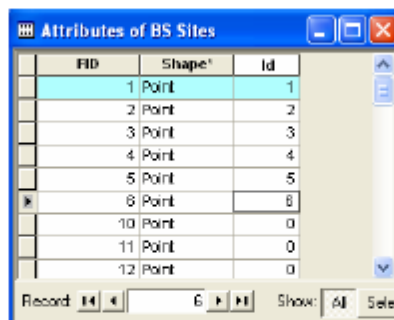
3. Click the Sketch Tool



4. Start to draw on the location of your sites
5. To move around the map use the navigation tools from the tool bar as normal, but remember to turn back on the sketch tool when you want to draw the location of another site.
  
6. After you have entered about three or four site locations you need to enter some data into the attributes table.
7. Right click on the layer name BS\_sites from the table of contents.
8. From the menu that appears choose **Open Attribute Table**. This will show you the number of points that you have entered so far.



- In the Id column of the attributes table type in the relevant site ID. For example, if you drew the location of your sites in the order that you visited then site No. 1 will have Id No. 1.



- From the Editor Toolbar, Click Editor and Save Edits.
- You can also use the identify tool to check the number given to a particular site drawn on your map.
- If you make a mistake entering the location of a point go to the editor toolbar. From the task menu choose reshape feature.



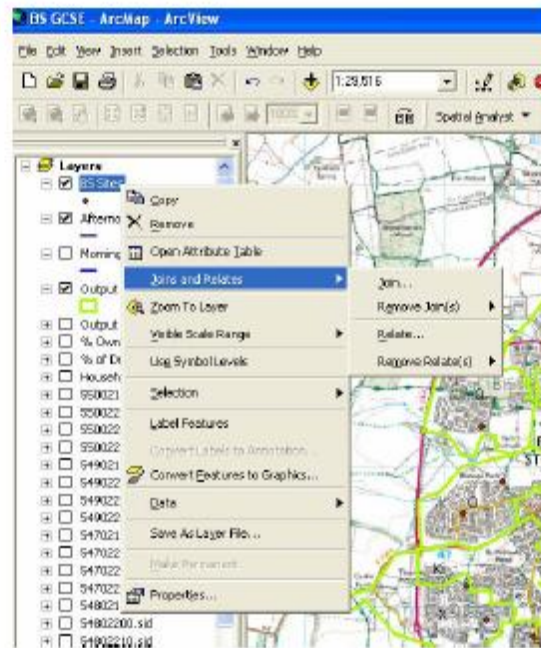
13. Click on the **edit tool** from the toolbar menu.



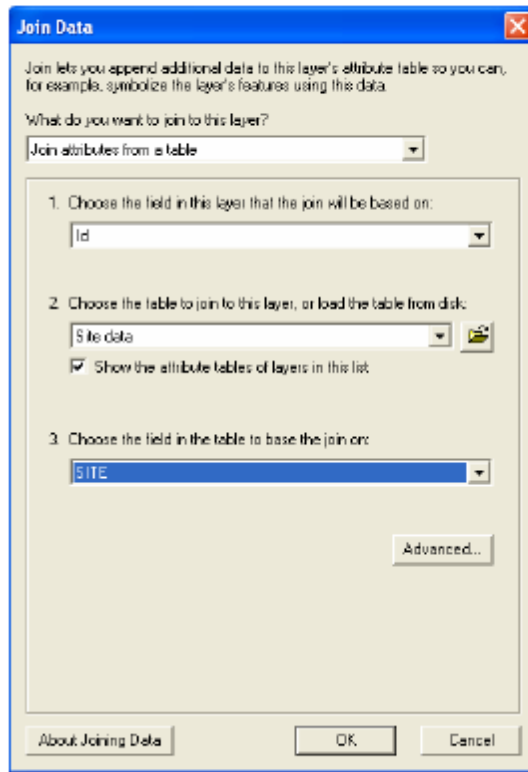
14. Click on the site point that you want to move and then drag it to a new location.
15. If you want to delete a point, click on the point with the edit tool, right click with the mouse button and choose delete.
16. Remember to change the task in the editor toolbar back to Create New Feature and select the sketch tool when you want to start drawing more points.
17. When you have finished adding your site locations to the map click **Editor, Stop Editing**.
18. Click **Yes** to save edits to BS\_Sites.

Join a table to a map

1. In the ArcMap table of contents, right click BS Sites layer, then click **Joins and Relates, Join**.



2. In the Join Data dialog, make sure that Join attributes from a table is chosen from the drop-down list at the top of the dialog box.



3. For step 1, choose the Id field from the drop-down list.
4. For step 2, browse and choose the Site data Dbase file that you created earlier.
5. For step 3, choose the site field, click OK
6. Click the advanced button from the join data menu
7. Click keep only matching records, click OK
8. Click OK on the Join data menu
9. You will be asked: do you want to create an index, select NO.
10. Right click on BS\_sites and open the attribute table.

## B. Constructing the tsunami – Pupil Guidance



## **South Asian Tsunami**

A GIS investigation

1) ArcGIS - Pupil Guidance

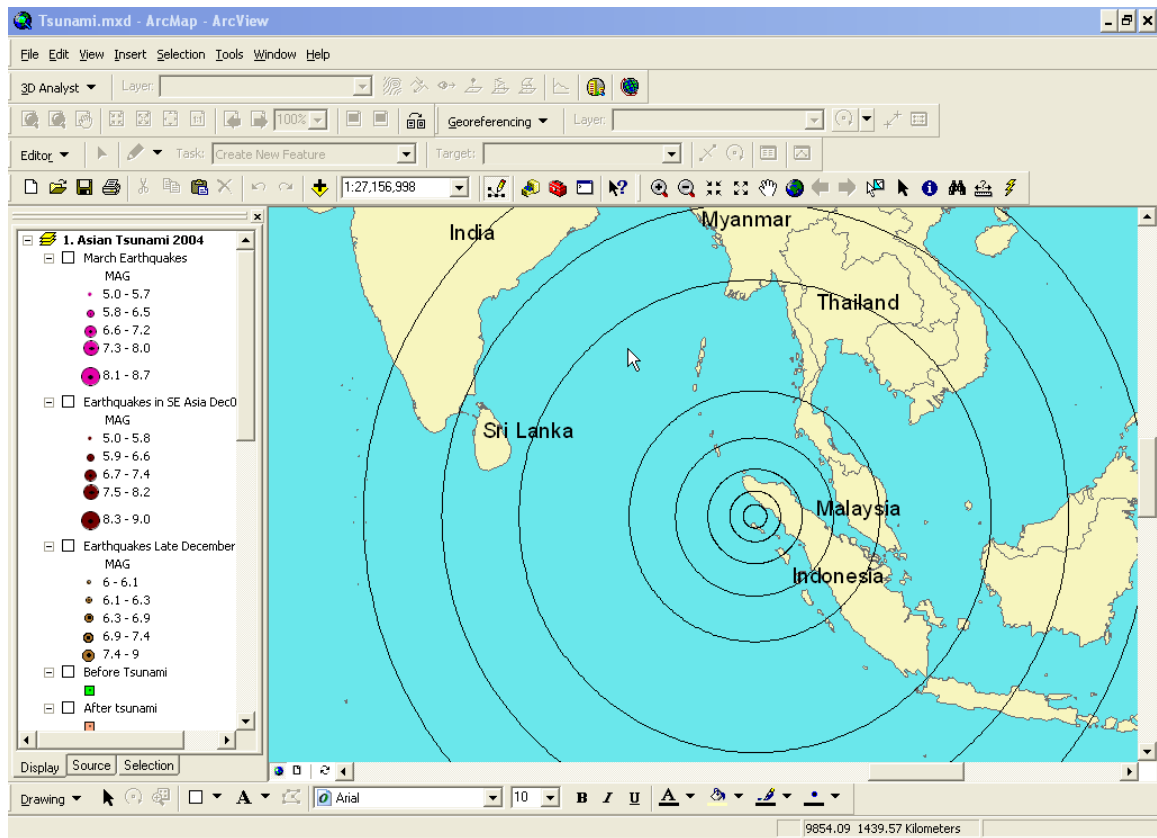
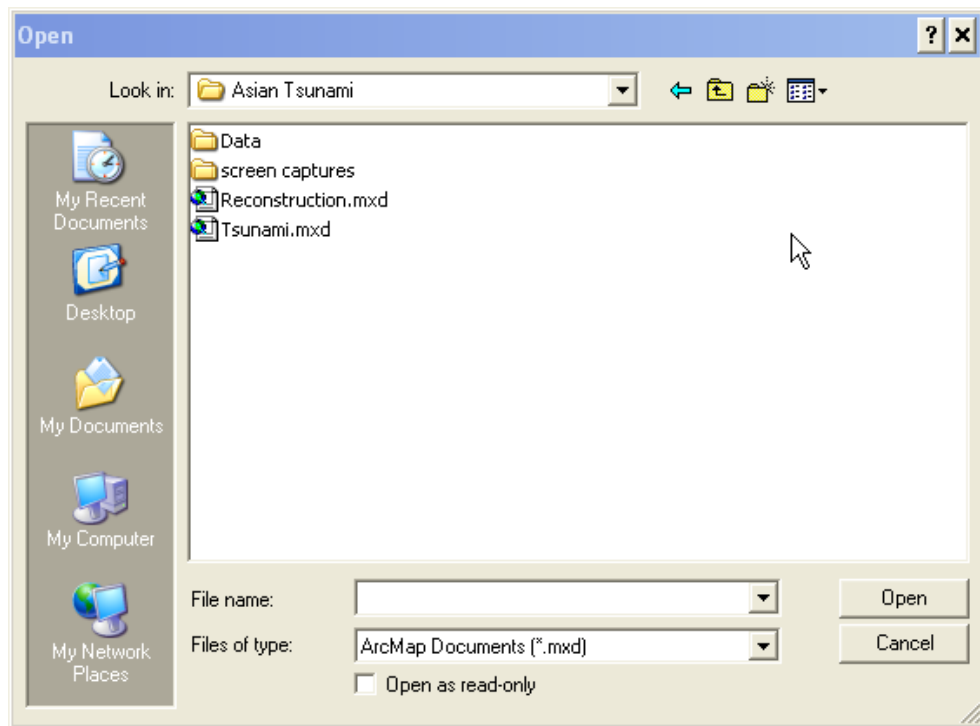
### **Project - The 2004 South Asian Tsunami**

#### **Step 1 Start Arcview**

a) Double Click on the Arcmap icon on your computer desktop



b) If the welcome to Arcview dialogue box appears, Click **Open an existing Project** and click **OK**.




## Step 2 Examining the Data

a) Using the Table of Contents answer the following question.

**(1) Which two major plates caused the Earthquake along the coast of Sumatra?**

b) Turn off the **Asian Plates** theme in the Table of Contents by clicking on the check box , which will remove the tick from the box.

c) Turn on the **Area Affected** and **Earthquakes-Aftershocks 26/12-31/12** by clicking on the check box . Use the **Measure Tool**  to find out the following distances.

**(2) a) Epicentre to closest Coast of Sumatra**

**b) Epicentre to Banda Aceh**

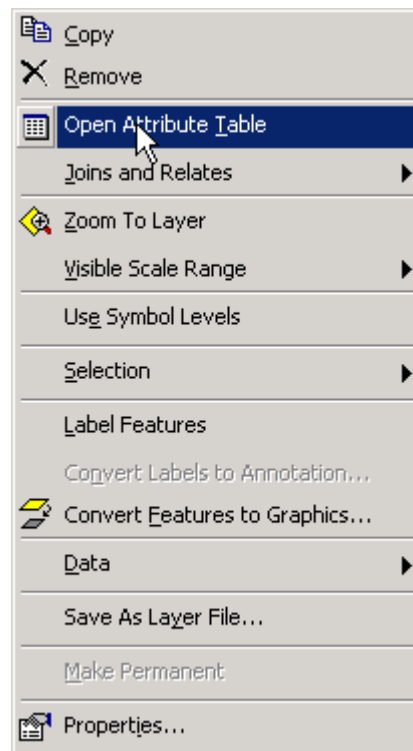
**c) Epicentre to Phuket**

**d) Epicentre to East Coast of Sri Lanka**

**e) Epicentre to Madras**

**f) Epicentre to Colombo**

d) Right click on the **Earthquakes-Aftershocks 26/12-31/12** theme to access the drop down menu. Click on **Open Attribute Table**. This allows you to examine the data behind the theme.

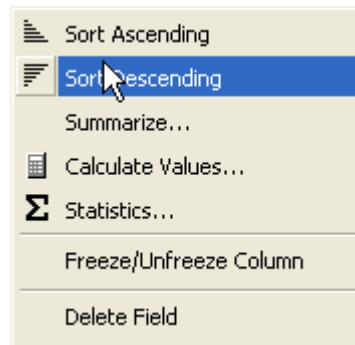


FID	Shape^	YEAR	MONTH	DAY	TIME	LAT	LONG	MAG	DEPTH
0	Point	2004	12	26	005853.45	3.3	95.98	9.0	30
1	Point	2004	12	26	011710.33	4.94	94.27	5.5	30
2	Point	2004	12	26	012120.66	6.34	93.36	6.1	30
3	Point	2004	12	26	012225.59	7.42	93.99	6.0	30
4	Point	2004	12	26	012548.76	5.5	94.21	6.1	30
5	Point	2004	12	26	012952.94	20.91	97.71	5.8	38
6	Point	2004	12	26	013015.74	8.83	93.71	5.5	30
7	Point	2004	12	26	013322.38	7.76	93.71	5.5	25
8	Point	2004	12	26	014007.13	5.84	93.15	5.3	30
9	Point	2004	12	26	014852.07	5.43	94.46	5.7	51
10	Point	2004	12	26	015243	10.38	92.12	5.2	12
11	Point	2004	12	26	015913.99	8.39	92.45	5.3	30
12	Point	2004	12	26	020040.03	6.85	94.67	6.0	30
13	Point	2004	12	26	021523.57	6.17	93.47	5.6	30
14	Point	2004	12	26	021549.50	12.26	92.28	5.3	20
15	Point	2004	12	26	021559.78	12.32	92.5	5.7	26
16	Point	2004	12	26	022204.84	8.87	92.47	5.7	15

Record: 0 Show: All Selected Records (0 out of Selected.) Options

(3) How many Earthquakes and Aftershocks occurred between the 26<sup>th</sup> and the 31<sup>st</sup> December? (Hint look at selected)

g) Click on the **Day** at the top of the 5<sup>th</sup> column, a black outline will appear. Right click on the **Day** and a drop down menu will appear. Click on **Sort Ascending**.



(4) How many Earthquakes and Aftershocks occurred on the 26<sup>th</sup> December?

h) Click on **Mag** at the top of the 9<sup>th</sup> column, a black outline will appear. This time use the **Sort Descending**.

(5) The two most severe occurred on the 26<sup>th</sup>, what were their Magnitude and Depth?


(6) When did the next most severe Earthquake or Aftershock occur and what was its Magnitude and Depth?

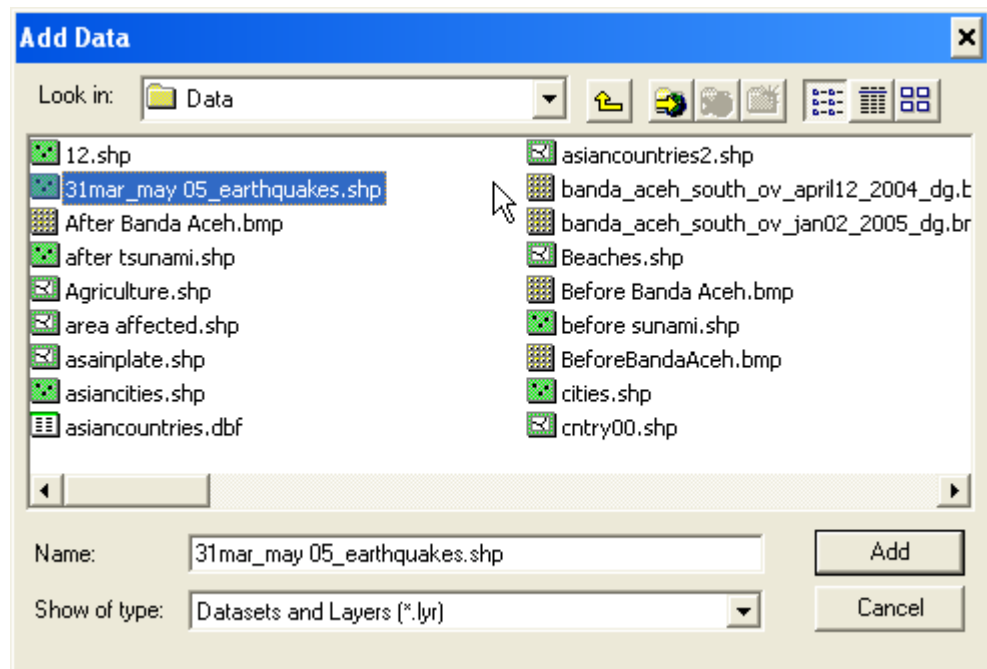
(7) What was the range of Magnitudes and Depths during this time?

j) Turn on the Earthquakes 26/12/04 to 31/3/05 theme.

(8) What has occurred in the three months after the major earthquake that happened on the 26/12/04?

(9) Predict what you think will happen in the next month and a half. Write a half page stating whether and where you believe earthquakes will occur.

k) Click on the Add Theme icon  and you need to guide the directory to **Asian tsunami arcview3\data** and click on **31mar\_may05\_earthquakes** and click **OK**. A new theme will appear in the table of contents (See Below).

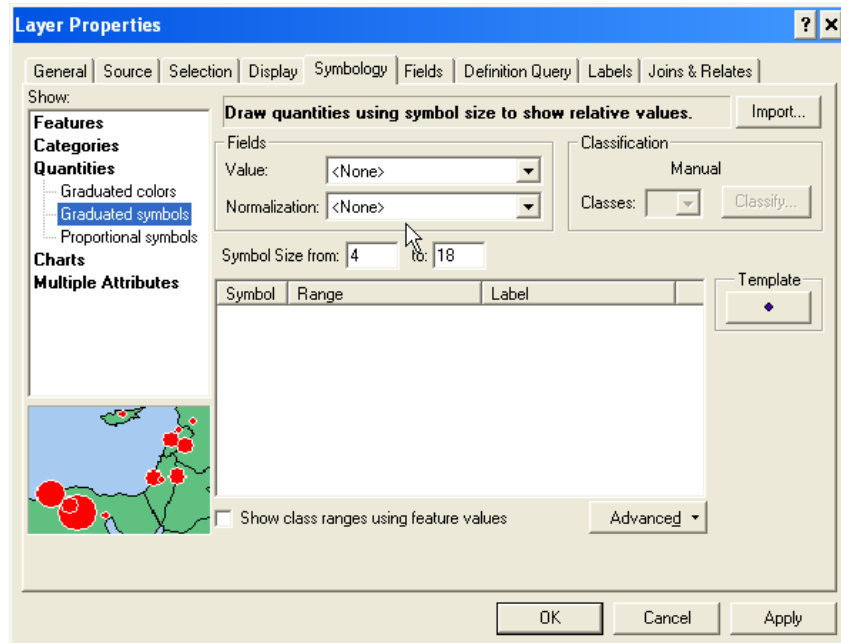


#### 1. Asian Tsunami 2004

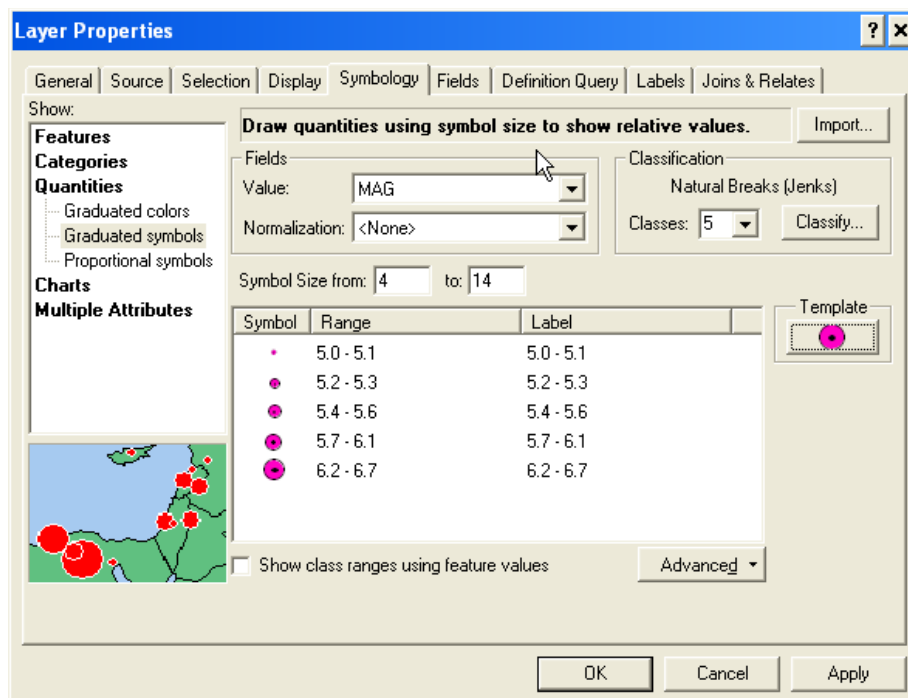
- 31mar\_may 05\_earthquakes**
- Cities after Tsunami
- Cities Before Tsunami
- Coastal towns

l) Double click the label (Highlighted above) in the new theme. This will generate the Layer Properties table. Make sure **Symbology** tab is highlighted.

m) Then in the show column on the left hand side, click on **Quantities** and then **Graduated symbols**.



n) Click on **Value** to access the drop down box and select **MAG**. Change maximum symbol size from 18 to 14. Click on **Template** and change the icon. Click **OK**.




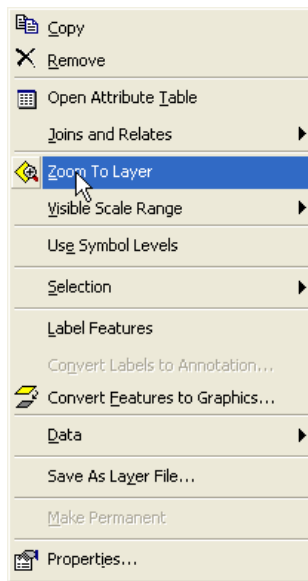
o) Drag the new theme **31mar\_may05\_earthquakes** down beneath **Earthquakes 26/12/04 to 31/3/05** by simply clicking and dragging the theme.

- Asian Cities
- Indonesia
- Earthquakes-Aftershocks 26/12/04 to 31/3/05
  - MAG
  - 5.0 - 5.2
  - 5.3 - 5.5
  - 5.6 - 5.9
  - 6.0 - 6.6
  - 6.7 - 9.0
- Earthquakes 26/12/04 to 31/3/05
  - MAG
  - 5 - 5.2
  - 5.2 - 5.6
  - 5.6 - 6.3
  - 6.3 - 7.5
  - 7.5 - 9
- 31mar\_may 05\_earthquakes
  - MAG
  - 5.0 - 5.1
  - 5.2 - 5.3
  - 5.4 - 5.6
  - 5.7 - 6.1
  - 6.2 - 6.7
- Area Affected
- Population Density

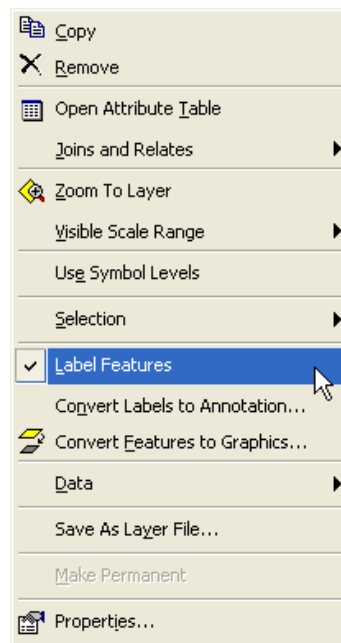
**(10) Write a page describing the pattern of earthquakes from the 26/12/04 to 11/5/05 using the data.**

#### Step 4. Cities Affected in South Asia

a) Turn on Asian Cities and Population Density. Right click on **Area Affected** and then click on **Zoom to Layer**. Then click on the **Fixed Zoom in** icon , this will zoom in to a better scale for the next task.




- b) Right click on Asian Cities to access the drop down menu, click on the **Label Features**.

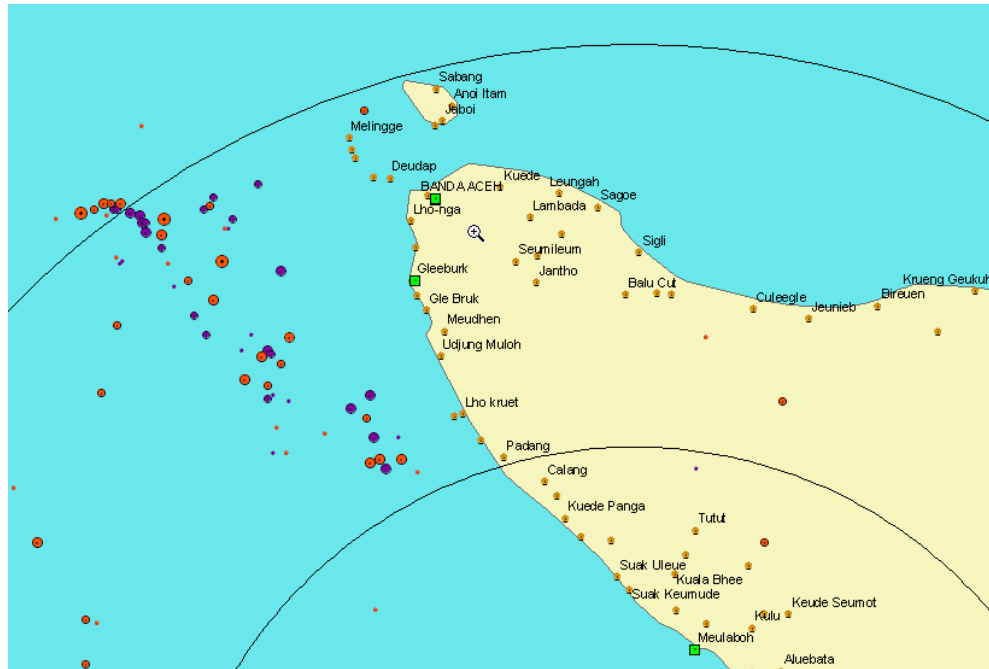




- (11) Rank the five Cities you believe were the most severely affected by the tsunami from most to least severely affected and state why?
- c) Turn off the **Population Density** and turn on **Countries with Deaths** to help with this task.

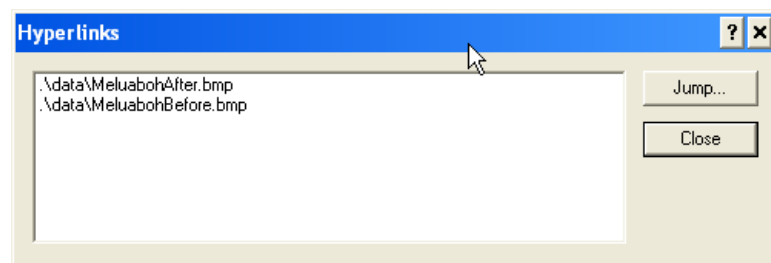
### Step 5. Using Hotlinking in ArcView 9.0



- a) Zoom into Banda Aceh region using the Zoom in tool 
- b) Turn on the **Before Tsunami** theme and the **Indonesian Coastal Towns** theme.



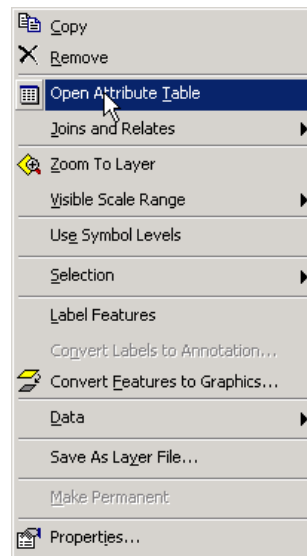
- c) The Hotlink icon  becomes active when these layers are active. Click on the icon and then click on the **Meulaboh** point and examine the before images of the city. Use Microsoft Office Picture Manager to examine the image. Use the zoom and scroll to examine the image more closely. Repeat the process for **Gleebruk Village** and **Banda Aceh**. Turn off the **Before Tsunami** theme.
- d) Turn on the **After Tsunami** theme and repeat the process with the Hotlink.
- e) Turn on the **Before Tsunami** and **After Tsunami** themes click on the Hotlink icon . Click on **Meulaboh** and scroll through the images of before and after the tsunami. If the Hyperlinks box appears click on the `.\data\MeluabohBefore.bmp` and **Jump**.



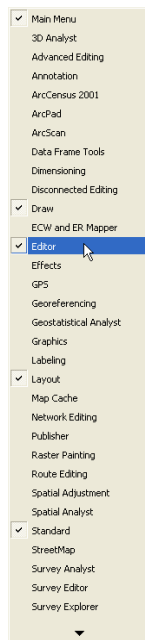
**TASK** You are an emergency response coordinator for the World Health Organisation (WHO) and the first person to receive images from Indonesia after the Tsunami. Choose either Meulaboh or Gleebruk Village and write a situation report for the area. Where is the area? What has occurred? How has it affected the Environment, Infrastructure and the People of the area? What are the immediate needs of the people? What are the problems in responding to the disaster? What are some of the long term initiatives?

### Step 5. Using and Manipulating Data

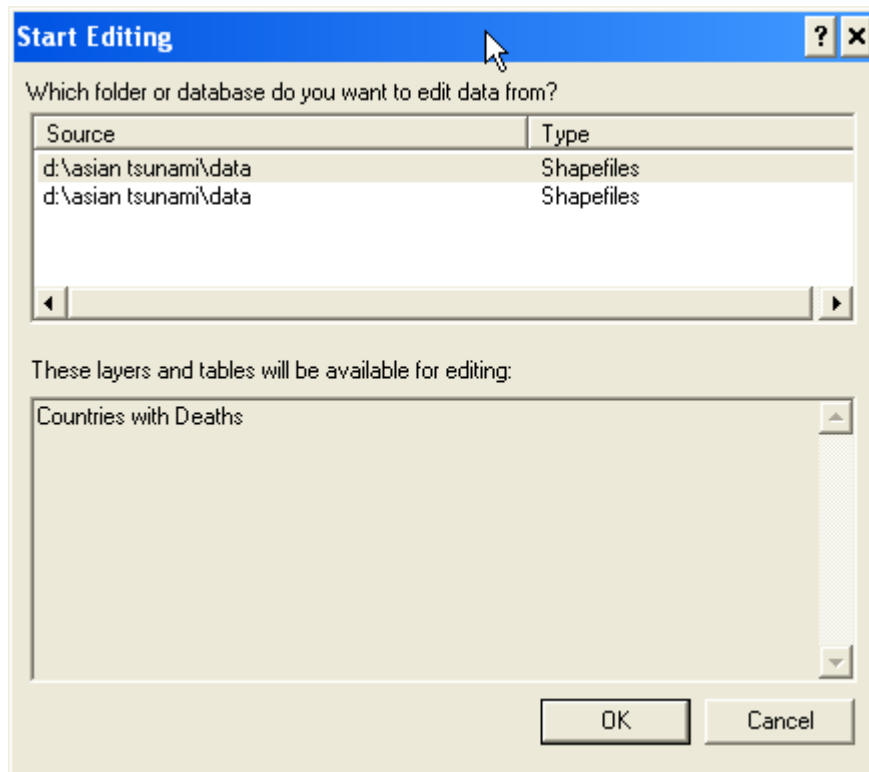
- a) Turn on the **Countries with Deaths** theme. Right click on the theme name and scroll down to **Open Attribute Table** and click. Examine the data in the table. Analyse the data and the World Health Organisation Situation Report 21 from the 18<sup>th</sup> January, 2005 and develop a rating system for the areas affected and write a short report on their needs.



- b) When the rating system is developed you need to enter the data. Make sure the editor tool bar is available. If its not right click on the grey area of the tool bar to access the drop down menu. Click on Editor and the Editor Toolbar will appear. Make sure the **Target = Countries with Deaths**, then click on the **Editor** drop down arrow.



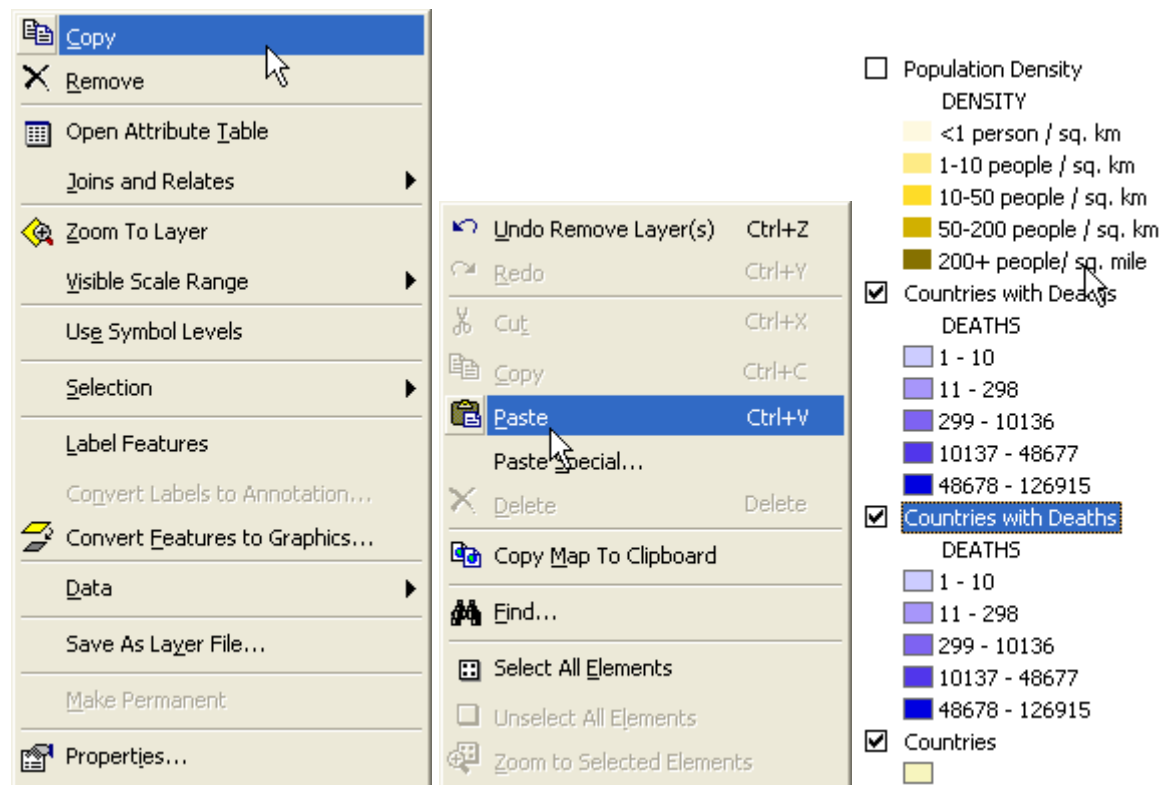
- c) Click on **Start Editing**. A **Start Editing** box will appear, if it looks the same as below click **OK** and start adding data.



Attributes of Countries with Deaths		
EST_CASUAL	LONG_NAME	AFFECTED_C
0	Bangladesh	
600	Myanmar (Burma)	
0	Sri Lanka	Serious
0	Malaysia	
0	Somalia	
0	Maldives	
0	Kenya	
0	Tanzania, United Republic of	
0	Seychelles	
0	India	
0	Yemen	
0	Indonesia	
0	Thailand	

Record: 2 Show: All Selected Records (0 out of 13 Selected.) Options

- d) When the table is complete, click on the **Editor** drop down menu and click on **Stop Editing**.
- e) Right click on the **Countries with Deaths** theme , then click on **Edit** and in the drop-down box click **Copy Themes**. Then click **Edit** again and scroll down to **Paste** and click. Go to the top of the Table of Contents and drag the copied theme down to the Countries with Deaths theme



f) Double click on the **Countries with Deaths** theme title to bring up the **Layer Properties box**. The Symbology Tab on the Layer Properties box is used to manipulate the data sets available in the table of the theme. In the **Show** box on the left hand side a number of displays are available.

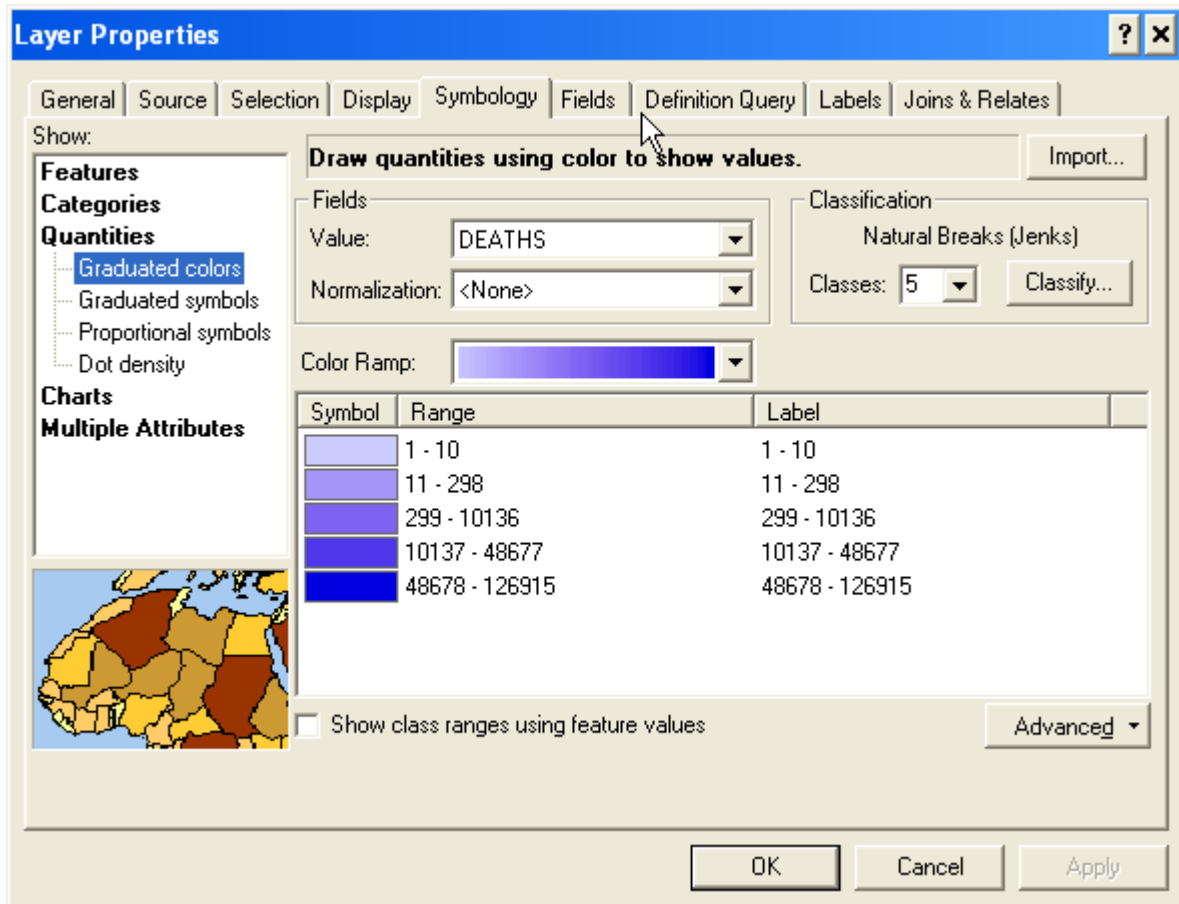
Features = Single Symbol

Categories = Unique Value for each different field

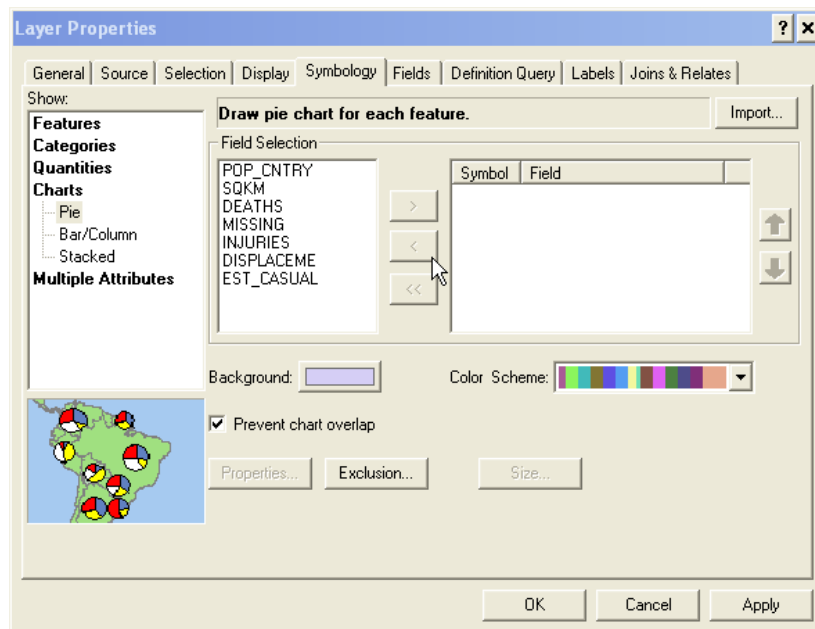
Quantities = Graduated Colors, Graduated symbols, etc.

Charts = Pie charts, Bar Graphs, etc.

Multiple Attributes



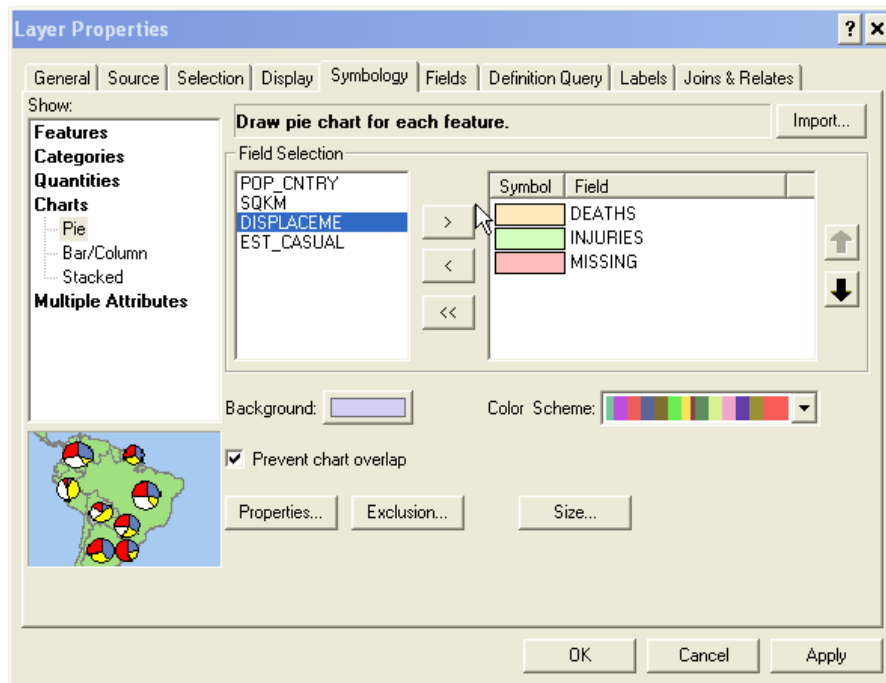
g) Click on **Charts**, then **Pie**.



h) In the field selection choose Deaths, Injuries and Missing using the move button



to take them into the box as below. Then click **OK**.



## Step 6. Using Maps

a) Use the Map below to suggest answers to the following questions.



# South Asian Tsunami 2004



(12) Which three countries would be most likely to have their death toll rise the most and why?

**(13) Which three countries had the largest percentage of injuries?**

**(14) Which two countries had the highest percentage of deaths and suggest why?**

**(15) Which countries were most in need of medical aid looking at these percentages and why?**

### **HYBRID GIS TASK**

You are an emergency response coordinator for the World Health Organisation (WHO) and the first person to receive images from Indonesia after the Tsunami. Choose either Meulaboh or Gleebruk Village and write a situation report for the area. Where is the area? What has occurred? How has it affected the Environment, Infrastructure and the People of the area? What are the immediate needs of the people? What are the problems in responding to the disaster? What are some of the long term initiatives?

### **REPORT STRUCTURE**

#### **Introduction**

What has occurred? Where is the site you are examining? (Use Maps)

#### **Assessment of Situation**

#### **Health Issues**

#### **Social Issues**

#### **Political Issues**

#### **Environmental Issues**

#### **Economic Issues**

#### **Summary**

What are the priority needs for the area?

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II Google Earth – Pupil Guidance



#### **2004: Thousands die in Asian tsunami**

‘Massive sea surges triggered by an earthquake under the Indian Ocean have killed over 10,000 people in southern Asia, with many more feared dead.

A 9.0 earthquake occurred under the sea near Aceh, north Indonesia, at 0759 local time (0059 GMT) generated the biggest tsunami the world has seen for at least 40 years.

The wall of water fanned out across the Indian Ocean at high speed and slammed into coastal areas with little or no warning. ‘

(Source:

[news.bbc.co.uk/onthisday/hi/dates/stories/december/26/newsid\\_4631000/4631713.stm](http://news.bbc.co.uk/onthisday/hi/dates/stories/december/26/newsid_4631000/4631713.stm))

**Control + click this link:**

[http://upload.wikimedia.org/wikipedia/commons/3/39/2004\\_Indonesia\\_Tsunami.gif](http://upload.wikimedia.org/wikipedia/commons/3/39/2004_Indonesia_Tsunami.gif)

**to view an animation of the tsunami waves spreading across the Indian Ocean**

## Step 1: MAPPING THE COUNTRIES AFFECTED BY THE TSUNAMI

Control + click this link:

<http://www.geographyteachingtoday.org.uk/images/activities/hazard01.html>

- 1) Using the interactive map, label some of the countries affected by the tsunami which are located around the Indian Ocean
- 2) How fast was the tsunami travelling?

## Step 2: HOW WERE COUNTRIES AROUND THE INDIAN OCEAN AFFECTED BY THE TSUNAMI?

The point on the earth's surface where an earthquake is first felt is called the **EARTHQUAKE EPICENTRE**.

- 3) Use the onscreen information to complete the following table:


<b>COUNTRY AFFECTED</b>	<b>DISTANCE FROM THE EPICENTRE</b>	<b>LOCAL TIME TSUNAMI HIT</b>	<b>TIME IN LONDON - GREENWICH MEANTIME (GMT)</b>	<b>NUMBER OF DEATHS</b>

- 4) Using examples describe and explain the connection between number of deaths in each country and distance from the earthquake epicentre.

Open **GOOGLE EARTH**

Click 'Borders and Labels' in the left-hand menu.

Fly to Banda Aceh, Indonesia. This is the location of the nearest large city to the earthquake focus. The nearest land to the earthquake's epicentre is Sumatra (Sumatra). Sumatra is the largest island entirely in Indonesia.

5) Use the measure tool  to measure the shortest distance between the earthquake epicentre and the coastline of Sumatra in kilometres.

### **Step 3: TECTONIC PLATE BOUNDARIES NEAR SUMATRA**

The earth's crust is made up of **TECTONIC PLATES** which move together, apart and side-by-side – often producing earthquakes.

**Control + click this link:**

<http://bbs.keyhole.com/ubb/download.php?Number=791659>

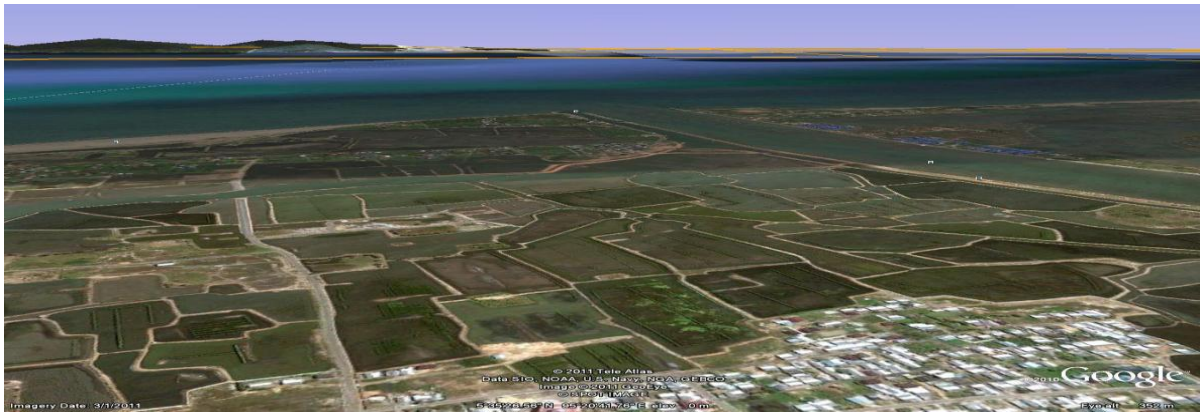
6) Which three tectonic plates meet near the epicentre of the earthquake which caused the Boxing Day tsunami?

### **SECTION 4 : IMPACTS ON PEOPLE**

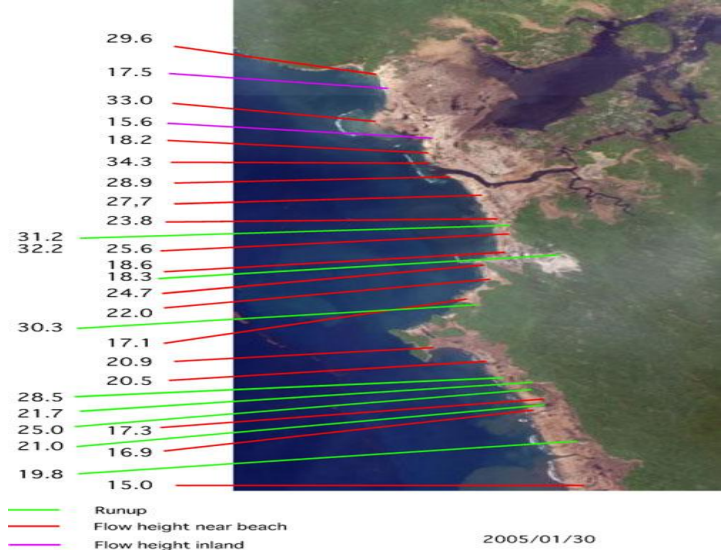
7) Read the report and using your data write a report on the key impacts of the tsunami:

**Control + click:**

[http://www.tsunami-evaluation.org/NR/rdonlyres/ED0ED010-E4DD-4FE0-ADA5-B60570553F2D/0/tsunami\\_stats\\_facts.pdf](http://www.tsunami-evaluation.org/NR/rdonlyres/ED0ED010-E4DD-4FE0-ADA5-B60570553F2D/0/tsunami_stats_facts.pdf)



The Banda Aceh Coastline (Google Earth)



Wave-run-ups at Banda Aceh.

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A4 – Data Coding

## 1. Coding Data

### 2. Open coding of initial data categories

Two initial data categories connected to the two research questions were identified:

**Table 1 Research questions and initial data categories**

Research Question	Initial data categories
How does GIS influence how teachers teach about place?	Teaching, Learning
How does GIS influence how pupils interpret place?	Place constructs

### 1. Pattern matching and abductive coding

Each data source – (observations, interviews, researcher journal extracts) were indexed/coded with topics discussed indicated line by line. Before each code was applied, earlier codes were compared and combined if they shared similar meaning. The indexing of topics allowed for collation of these across the series of data. The less frequently occurring themes were subsequently defined as sub-topics of the overarching categories of teaching, learning, place constructs. These initial categories were chosen as a way of organising initial data analysis in line with the two research questions.

### 2. Constant comparison analysis

Firstly, data (interview transcripts, observation notes and journal extracts) were coded.

Initial coding of student interview Data

Chunks (Student interview data)	Code for each chunk
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'It's so easy because you just type into the fly to box – a place or click on a video'	Technical ease (Tspd)
'ArcGIS was a bit confusing when you had to find things in the tables'	Technical challenge (Tso)
'In Google Earth you could see the places in 3D'	Visualising place (Vp)
'The physical shape (of the town) has changed over time'	Configurational knowledge (CKn)

The initial data categories are displayed with their coding in Table 2.

**Table 2 – Categories and codes**

Teaching	
Challenges	GISCh
advantages of using ArcGIS	GISAd
and Google Earth,	
problems using school network,	GISCh
relational representation	RelatRepr
configurational GIS	ConfigGISKn
mechanical scale	Mechsca
large scale geographical space as manipulable,	GeogSpa
spatial modelling	Manip
navigating in GIS space	Mod
	Navig
TPACK in researcher journal – linking content technology teacher particularly TCK	Tpck

(related to data collected through Spatially Speaking)	SpSk
Hybrid GIS:	hyb
Hybrid GIS combining ArcGIS and Google Earth, new emerging technology multi-platform	hyb
Geovisualisation	geovis
New uses of scale	sca
<b>Learning</b>	
Enquiry Using mechanical scale prediction of earthquakes volunteered knowledge navigating map space creating my place processing knowledge through GIS, locational analysis, quantification  learning spatial concepts, cognitive load implications	Enq Sca Gckn VGI Geospa Autlrn Tckn Locana Quant  Spatsk CogL
<b>Place constructs</b>	
descriptive place quantitative place Home School , famous landmarks, place as a local area,  place as distant, place on the map, place on satellite imagery representations of place bias, sources, National curriculum, relational place,	DesP QuantP LocP LocP LocP  distP mapP SatP RepP Bia Srce NC RelP

volunteered place,	VGI
virtual place,	VirtP
inter-connected place,	IntP
place as digital atlas,	DigAtP
place as a product of relations,	RelP
hybrid gis	Hyb
space and place as open and connected	RelP











