Conceptions of geographic information systems (GIS) held by Senior Geography students in Queensland.

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Doctor of Philosophy

by

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ABSTRACT

Geographical Information Systems (GIS) represent one of the major contributions to spatial analysis and planning of the new technologies. While teachers and others have viewed its potential contribution to geographical education as considerable, it has not been known with any certainty whether they present a valuable educational tool that aids geographical education. The value of GIS to geographical education is viewed as depending on a geographical education being, in itself, valuable.

Within this context, synergetic focus groups are employed to explore the conceptions of GIS held by 109 secondary school students studying Senior Geography in metropolitan and regional Queensland, Australia. A phenomenographic approach is adopted to identify the six qualitatively different ways, or conceptions, in which the participating students experience GIS as:

1. *Maps and a source of maps in geography.*
2. *Mapping in geography: a way to use and create maps.*
3. *A professional mapping tool: exceeding the needs of senior geography.*
4. *Frustrating geography: irksome and presenting many challenges to the student-user.*
5. *Relevant geography: within and beyond the school experience.*
6. *A better geography: offering a superior curriculum, and broader geographical education, when contrasted to a senior geography that omits its use.*

The structural and referential elements of each of these conceptions are elucidated within corresponding Categories of Description. The qualitatively different ways in which the conceptions may be experienced are illustrated through an Outcome Space, comprising a metaphoric island landscape. This structural framework reveals that for the Senior Geography students who participated in this investigation, the extent to which GIS may augment the

curriculum is influenced by the nature of students' individual understandings of how GIS manages spatial data.

This research project is a response to repeated calls in the literature for teachers of geography themselves to become researchers and for a better understanding of GIS within geography education. It reviews the salient literature with respect to geography and geography education generally, and GIS within geographical education specifically. The investigation has confirmed that qualitatively different conceptions of GIS exist amongst students and that these are not consistently aligned with assumptions about its use and benefits as presented by current literature.

The findings of the study contribute to knowledge of the potential educational outcomes associated with the use of GIS in geography education and decisions related to current and potential geography curricula. It provides guidance for future curriculum development involving GIS and argues for additional research to inform educators and the spatial sciences industry about the actual and perceived role of GIS within geography education.

KEYWORDS

conceptions of GIS, geographical information systems, GIS, geography education, information and communications technologies, maps and mapping, phenomenography, senior geography, students, teaching and learning, qualitative research methods

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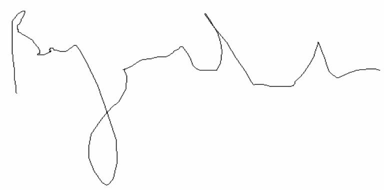
LIST OF ABBREVIATIONS

Abbreviation	Expanded form
BSSSS	Board of Senior Secondary School Studies
CCE	Common Curriculum Element
ESRI	Environmental Systems Research Institute
GIS	Geographical Information Systems
ICGE	International Charter on Geographical Education
ICT	Information Communications Technologies
IRGEE	International Research in Geographical and Environmental Education
IGU	International Geographical Union
KGI	Key Geographical Idea
NCGE	National Council for Geographic Education
NRC	National Research Council
QSA	Queensland Studies Authority
QUT	Queensland University of Technology
UNESCO	United Nations Educational, Scientific & Cultural Organisation

STATEMENT OF ORIGINAL AUTHORSHIP

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: 

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More than a decade ago, Gina Palmer introduced me to the idea of using GIS in the geography classroom. In that time, she has been a constant source of encouragement and motivation. Her steadfast belief in me has, doubtlessly, precipitated the following pages.

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Finally, this thesis is dedicated to 'Nowhere' (June 1997 – November 2006).

PUBLICATIONS ARISING FROM THIS RESEARCH

2006. Forum: Issues affecting the adoption of GIS within Australian and New Zealand schools. *International Research in Geographical and Environmental Education, 15*(3), 255-258.

2006. Conceptions of the "Role of Geography in the Future" held by Queensland Senior Geography students. *International Research in Geographical and Environmental Education, 15*(2), 104-123.

2006. Towards an understanding of the conceptions of GIS held by Senior Geography students in Queensland. In *Proceedings of a Conference on Changes in Geographical Education: Past, Present & Future Symposium* (pp. 467-471). Brisbane, Qld, Australia: International Geographical Union – Commission on Geographical Education.

2006. Conceptions of "productive classroom environment" held by middle school students at one independent Queensland school. *Australian Journal of Middle Schooling*, *6*(3), 8-14.

2004. GIS goes to high school. *Position Magazine*, *13*(October), 24-27.

2004. The contribution of a geographical education to regional sustainability. *Geographical Education, 17*, 15-23.

2003. Conceptions of the 'Role of Geography in the Future' held by Year 12 Geography students. *Geographical Education, 16*, 26-32.

2003. Student Attitudes and the Impact of GIS on Thinking Skills and Motivation. *Journal of Geography, 102*(6), 267-274.

CHAPTER ONE
INTRODUCTION: THE NATURE OF THE STUDY

This is a call for geography and environmental educators to think critically about the value of GIS (Bednarz 2004, p. 192).

Background to the issue

Preamble

The Queensland Senior Geography syllabus states that geography contributes to the development of content, cognitive processes, skills and values that "help students to better explore, understand and evaluate the social and environmental dimensions of the world" (Queensland, 1999a, p. 2). More specifically, Standard One of the US National Geography Standards stipulates that a geographically informed person knows and understands "how to use maps and other geographical representations, tools and technologies to acquire, process and report information from a spatial perspective" (Geography Education Standards Project, 1994). While it seems like a good idea, teaching these spatial skills is at once the most difficult and, yet, arguably the most important aspect of a geographical education (Oldakowski, 2001).

Since much of what is taught and the manner in which it is taught in geography classrooms is motivated by each teacher's perceptions of purposefulness (Salter, 1995), we need, as educators, to ensure that decisions regarding the geography curriculum are based on correct assumptions. As yet, however, and despite frequent assertions in professional literature, it is not known with any certainty the extent to which increasingly commonly used technologies present valuable educational tools that allow students to develop spatial skills.

Geographical Information Systems (GIS) represent one of the major contributions of the new technologies to spatial analysis and planning. However, while its impact on the nature of geography education in schools has been, as yet, “negligible” (Dascombe, 2006; Kidman & Palmer, 2006; Wiegand, 2001, p. 68), it is generally viewed as offering a positive contribution to both geography students and the subject itself (Baker, 2005; Baker & Bednarz, 2003; Jenner, 2006; Kerski, 2001; Nellis, 1995; West, 1998a, 2003b). While issues of cost, access, skill and time present obstacles for many teachers, the teachers themselves view the technology as offering many more positives than negatives to learning (Freeman, 2006; Kerski, 2001; Meaney, 2006; McInerney & Shepherd, 2006; Smerdon, 2006).

Ten years ago, Murphy (1997) called for systematic research to evaluate the contribution of computer-based instructional systems to student learning. In 2000, Shields & Behrman (2000) and Subrahmanyan, Krant, Greenfield and Gross (2000) both highlighted the need for increased access to increasingly sophisticated technologies to be matched with an increase in research to determine whether this access has a demonstrably favourable influence on learning experiences at school. More recently, and of specific relevance to the current study, the editors of a 2003 special edition of *Journal of Geography*, focusing on research in GIS in education, noted that the merits and barriers of including GIS in the classroom had been frequently identified (Baker and Bednarz, 2003). However, they also observed that despite the widespread promotion of its use, GIS technologies remain peripheral to most geography education. One reason, they claim, is the “paucity of research on its effectiveness in promoting significant learning” (p. 232).

In response to this, the present study explores the nature of geography and the possible role of a geographical education. It will then investigate the potential role that GIS could play in a geographical education. Within this context, discursive analysis of student conceptions of GIS will identify whether using GIS in Queensland Senior Geography aids in students’ geographical education.

The Role of a Geographical Education

Three decades ago, Blachford (1971) asserted that "it is in the fullest development of the mind that geography seems to have a place in the curriculum" (p. 216). To justify the continued validity of such a statement requires that the study of geography be shown to be worthwhile. In this regard, Naish, Rawling and Hart (1987) more recently devised three criteria by which the inclusion of any subject in the school curriculum could be justified:

1. it should be concerned with a body of knowledge of genuine significance;
2. it should be capable of developing students' skills and capabilities; and,
3. it should open up opportunities for values education.

Research over the past century has shown that school geography <u>can</u> meet all three criteria. Through the study of physical and cultural environments at a range of scales, students are exposed to a diversity of knowledge. In Queensland's Senior Geography syllabus, for example, this knowledge extends beyond naming places and describing physical phenomena to developing students' conceptual understandings of the relationships inherent in human-environment interaction.

Also, the value statements included in most Australian syllabuses suggest that the final criterion of Naish *et al.* is an integral goal of school geography. For example, the Queensland Senior Geography syllabus includes six educational assumptions, the fourth of which declares that "[e]ducation for societies and environments also entails affective aspects of human behaviour in which feelings and values are prominent. They include feeling for and enjoyment of landscape and the formation of values underpinning human and environmental justice" (p. 3). Assumption two also refers to the role of values in geographical education, whereby "students already have a range of geographical skills and values simply because of their daily experiences with people and environments. Geography develops these understandings and abilities to enable students to fulfil their potential as inhabitants of a finite world" (p. 2).

In these regards, to resolve issues arising from human-environment interactions, students of geography are encouraged to analyse the values underlying the various points of view contributing to the conflict. Hence, through studying real-world issues, students can be exposed to the influence of attitudes and societal power structures upon decision-making processes. Consequently, they may be well positioned to acquire the skills necessary to consider the role of their personal values and attitudes in shaping the world in which they live.

Beyond the three stated criteria, geography has further extended its value in the school curriculum. As Naish *et al.* (1987) expound:

> geography's function in the curriculum [is] as a discipline which asks and tries to answer questions specific to its own interests, but at the same time provides the opportunity for the development of more general understanding and capabilities.

In this regard, Geography is at once a social and a physical science. Through a geographical investigation, students identify processes from many disciplines, examine human impacts, and devise recommendations for the resolution of issues. To this, Piper (1994, p. 346) adds that geography should

> focus on [the] potential contribution to an education for social competence and initiation into the life of the wider society, not in specialised knowledge and initiation into an academic culture.

To foster skills in social competence, Macaulay (1994) asserts that students in geography should be encouraged both to practise a wide range of skills and to make "frequent use of higher-level thinking skills" (p. 23). As such, geographical study provides a mechanism by which the individual may reason both *in* and *with* geography (Gregg, 1997, original emphasis); generating other geographical information, and providing spatial insight.

Assuming Piper's assertion is credible, and effective investigation requires student use of various skills and tools, it becomes incumbent upon geographers to identify and apply those skills and tools that meet his inferred criteria. To this end, Kam (1996) emphasises the importance of spatial patterns, spatial interactions and spatial processes; concepts and skills which might be better understood through interactive manipulation of spatially referenced data (Laurence, Shaffer, Morrill & Fox, 1993).

Geographic Information Systems

One tool which may assist geography students to achieve the aims of their chosen subject is that provided by geographic information systems (GIS). Indeed, some would argue that "it is essential for students to have exposure to good geography using current resources, ... and with easy access to integrated technologies such as GIS" (Freeman, 2006, p. 187).

It is the domain of GIS to unite any spatial data that can be referenced by geographical coordinates. In its purest form, GIS refers to the combination of various forms of geographical data, such as aerial photographs, statistics and maps. In recent years, however, GIS has become more synonymous with computer technology. Although possessing different degrees of sophistication, the various GIS software products perform essentially the same function: encoding, management and manipulation of spatial data (Curran, 1985). Similar definitions are proffered by ESRI (1991), Gerber (1995a), National Research Council (2006), Pun-Cheng and Kwan (2001), and West (2003b).

GIS configure data to link place with meaning clearly. As with all maps, maps developed using GIS are meaningless without their features being defined. For example, in the *ArcView* GIS package, each discrete element of the map constitutes an *Attribute*. Attributes are grouped to form *Themes*. Within this GIS, the meaning of each attribute is linked with its spatial position through a *Table of Attributes*, with one table for each Theme. A single attribute could be part of many Themes, depending on the scale of the map and needs of the user. Links through the table also allow each attribute to be connected with other data, including, but not limited to, other tables of attributes, word-processed documents, photographs, spreadsheets, graphs, videos, multimedia presentations and websites.

For example, Longreach Police Station is an attribute. It could belong to the Theme, Police Stations, on a map of Queensland. Its address, staffing allocation, budgetary allocation, photograph and links to active case files could be included in its Table of Attributes. Similarly, the same attribute could also be part of the Theme, Government Buildings, on a map of Longreach town centre. In this situation, it may have other information stored in its Table of Attributes, such as address, garbage collection dates and date of last fire extinguisher inspection.

While much has been written about the application of GIS to resource management and planning, and of the need to create professionals skilled in its use (Baker, 1997a, 1997b; Skelly, 1996; West, 2004a), its role in geography education is yet to be clarified.

Recent work regarding its use in schools has, however, suggested that it offers some educational benefits. GIS may support increased intrinsic motivation and higher level thinking processes. Such motivation may arise from student involvement in tasks that: possess relevance to their immediate studies (Meaney, 2006); are more appropriate to their needs (Jenner, 2006); use contemporary technologies (Baker, 2005); and, offer clear benefits beyond Senior Geography and beyond school (Kidman & Palmer, 2006).

Higher order thinking is necessary if geographical study is to provide a mechanism by which students may reason both *in* and *with* geography (Gregg *et al.*, 1997, original emphases). Unless "frequent use of higher level thinking skills" occurs (Macaulay, 1994, p. 23), students will generate neither the additional geographical information nor the spatial insight needed to manage uncertainty and resolve contemporary geographical issues. For higher level thinking to occur efficiently, the information being recalled must first have been configured (West, 1998a, 1999). Configuration involves the prioritisation of information and its subsequent placement into recognisable groupings. In geography, this commonly involves clusters or sequences being derived by attaching meaning to an object's relative or absolute placement (Gregg *et al.*, 1997).

Gregg *et al.* (1997) further suggest that the way that information is taught influences how that information becomes available. It is important to view the teaching of thinking in terms of what is required to enable efficient higher level thinking processes to occur. Heuristics are the generic cognitive strategies that we use to interpret information. If efficient heuristics are needed to allow successful evaluation and synthesis, then we are responsible for teaching the skills necessary for this to occur (West, 1999). If efficient evaluation and synthesis rely upon orderly configuration of data, then we should start there. Because GIS configures information based upon its spatial characteristics, it potentially models the thinking processes involved in geographical problem solving; GIS exposes students to more efficient heuristics. Since the successful use of GIS requires the use of these processes, it may be asserted that GIS users are likely themselves to develop more efficient processes for reasoning in and with geography (West, 1998a, 2003b).

Whilst such ideas may seem logical in theory, there exists an obligation for educators to be aware of students' attitudinal responses to various learning experiences. Indeed, attitudinal surveys of students in Australia and USA have failed to confirm categorically these assumptions (Baker & White, 2003; West, 2003b). While the results suggested statistically significant positive changes following use of GIS, the breadth of impacts was minimal.

More generally, more than a decade ago Jones & Clarke (1994) highlighted that simply providing secondary school students with access to computers does not guarantee their participation. This is a sentiment that has been echoed more recently by, amongst others, Baker and White (2003). Rather, it is essential for educators to determine the extent to which information and communications technologies (ICTs) offer more conceptually and cognitively relevant learning experiences.

Accordingly, investigation of students' conceptions of GIS is required. This is a call made also by the editors of the recent *Journal of Geography* special edition "Research on GIS in Education" (2003), who identified "the need for teachers to have a clearer understanding of students' cognitive processes, misconceptions and ability to make meaning from learning experiences using GIS" (Baker & Bednarz, 2003, p. 232). Specifically, the role of GIS in enhancing thinking in and with geography may be investigated through phenomenographic analyses. Mapping these conceptions will better define the likely educational outcomes associated with using GIS. Given the considerable costs involved in introducing and maintaining such technology in schools and the time that its use requires, decisions regarding the nature and extent of the further integration of GIS into curricula may be better informed.

Origin of the Study: Personal Experience

My first involvement with GIS was through analyses of remotely sensed (satellite) data using the *microBRIAN* software as part of a subject that I was undertaking as part of the Bachelor of Science degree in 1989. As with many undergraduate courses at the time, limited access to the computer hardware necessitated hour-long shifts in late night and early morning hours, booked weeks in advance. Binary data were classified into layers, classes allocated and maps generated. Accuracy was evaluated by the tedious process of ground-truthing; checking that the class edges matched the actual boundaries evident in the phenomena being mapped. These maps allowed greater confidence in decisions about resource use, since they enabled visual representation of the resources and related variables under various options. But it was tedious.

Eight years later, in 1997, I was charged with the introduction of *ArcView* GIS software to Windaroo Valley State High School's (WVSHS) Geography program. This required a great many hours reminding myself of the conceptual bases for encoding, managing and manipulating a range of spatially referenced data. Further hours were spent ploughing through commercially and publicly available data sets and creating smaller data sets suitable for in-class use.

Using GIS with students required the use of time that had been otherwise allocated for the prescribed curriculum. Specifically, the then (Queensland) Board of Senior Secondary School Studies (BSSSS) stipulated a minimum of 55 hours per semester for Senior Geography. The Work Program that WVSHS had developed in order to be accredited by BSSSS to offer Senior Geography did not allocate time to GIS. However, the school's administration supported risk-taking; would spending this time produce educational benefits at least equal to those produced by not using it?

Competition with other departments for access to the necessary computer resources was high. The network administrator needed to understand *ArcView*'s data handling procedures in order to determine how best to network the software and data to enable my learning objectives to be achieved. This required time. Students had no experience of digitised GIS. A task that would take a reasonably competent user one hour would take between four and six times as long with students. Student level of engagement at any one time could vary between highly occupied to using an Internet chat-room while waiting for me to get through the long queue of other students' technical questions.

However, repeated exposure of students reduced the instructional time required. Tasks became possible that were not otherwise available in class; the amount of data that could be analysed in the process of geographical inquiry greatly exceeded that available in the form commonly used in class. Tasks afforded a greater degree of relevance; students appeared to become more interested.

Anecdotal observations over the next few years suggested that students who had used GIS were 'better' at thinking. These students seemed to be able to use geographical information in such a way that they could generate plausible conclusions more rapidly than those students who lacked this experience. These experiences led me to question whether *ArcView*'s data handling and manipulation procedures also served to model a way of thinking efficiently for students.

Other teachers expressed interest. I presented a number of workshops and seminars, and hosted many teacher visits to introduce others to my experiences of using GIS. I believed that involving others would reduce the time and resource burden on any one teacher; that, somehow, a critical mass could be achieved, where schools would use GIS with as much ease as a word processor.

Since, 1997, I have spent many hundreds of hours planning and preparing GIS based learning experiences for students. Many more have been involved in sharing my experiences with others. The schools in which I have used GIS have committed very considerable amounts of both physical and human resources to supporting me in doing so.

However, whether using GIS is worth the effort for students is something that I have until now yet to determine. With this in mind, I have prepared a number of published manuscripts that discuss the potential impacts of GIS when used in secondary education. These identified the likely positives as being drawn from a combination of improved motivation and engagement . Motivation is seen as a potential result of being able to study a range of issues in greater detail and at a range of scales not otherwise possible, and by using computers. Engagement was suggested as arising from students being able to undertake aspects of geographical investigation at a level commensurate with their ability (West, 1999, 2003b).

Between 1999 and 2002, I undertook a quantitative study of over one hundred students from three-year levels at two Queensland schools. Students were surveyed using a five point Likert scale before and after exposure to GIS-related learning experiences. This revealed attitudinal improvements in three of these: perceived usefulness of computers, perceived control of computers and behavioural attitude to computers. The weighted average declined for the remaining two constructs: attitude to subject and affective attitude toward computers (West, 2003b).

While these data suggest that the use of GIS can exert a positive influence on students, since these data do not distinguish between the impact of using GIS and that of simply using computers, it remains unclear whether it was the GIS or the computers with which the GIS was used that had the greatest impact on student attitudes. If improved attitudes simply come from using computers rather than GIS specifically, perhaps it is worthwhile considering other, less technically difficult ICTs. In this regard, it remains of interest to me what students do think about GIS.

Rationale for the Current Study

Theoretical Imperative

Consideration of published opinion over the past decade would lead a reader to conclude that geography is a misunderstood subject with an image problem (see, for example, Conolly, 2000; Crabb, 1995; Dale, 1995; Fernald, 2002; Gerber, 1997; Hutchinson, 2006; Murphy, Morrison & Conolly, 2001; Rawling, 1997; Sabelli, 2001; Smerdon, 2006). Many authors suggest that to address its outdated image, curriculum development is required which emphasises geography's positive role in responding to many contemporary societal demands (Bliss, 2006; Rawling, 2000). Indeed, Harman (2003) asserts that "geography is only as valuable as its products are valued" (p. 419).

Four decades ago, Chorley and Haggett (1965) suggested that geographical research is one of the "main growth ingredients for the subject" (p. 375). Others have echoed this call. For example, in their review of the place of Geography within the Australian context, Hutchinson and Pritchard (2006) argued:

> for a future in which Australians are well-equipped to understand and adapt to the rapidly changing world, educational bureaucracies cannot afford to neglect geography. Not surprisingly in light of the fact that we inhabit an island continent like no other place on earth, the teaching and research of Geography in Australia traditionally has had a rich intellectual edge. Re-energising this edge … should be a national educational priority (p. 10).

Not long before, Baker (2003) called for further research to support the place of geography in the curriculum, specifying the need for data based upon appropriate research designs and methodologies; data that can be exposed to and withstand significant scrutiny. This research in geography education should establish an empirically sound, theoretically grounded, practical and relevant base of knowledge for geography (Downs, 1994).

Teachers would benefit from research which engenders for them greater confidence to make choices about which applications to use in their geography lessons, and how they can be used (Shields & Behrmann, 2000). International Geography Union (IGU) supports classroom-based research, publicly stating that it contributes to the "development and evaluation of teaching programs, processes and resources" (Stoltman, 1997, p. 38). To support teachers, this research would best consider actual classroom practice, including so-called new instructional techniques (Bednarz, 1997).

Education is costly. Research in any curriculum area ought to demonstrate that its cost is more than outweighed by its benefit (Downs, 1994). However, insufficient research exists about the effective teaching - subject knowledge relationship; how can teachers teach so that students learn what is intended (Rawling, 2000). Research should also be secondary in importance to the education (Underwood, 2004). In terms of the effectiveness and value of ICT educational research generally, Underwood discovered that a "lack of theoretical grounding and [its] individual, often idiosyncratic, nature" presented a significant weakness (p. 135). To address this, she emphasises the need for researchers to avoid four common pitfalls:

1. Disconnect between their research and theory;
2. Lack of consideration of the history of the issue being researched;
3. Focus on technology instead of learners and learning; and
4. Focus on quantitative methods.

Beyond research supporting its subject value, greater attention to learning processes is also required in geography (Sack and Petersen, 1998). Research is needed to "define which teaching strategies are most effective" (Nellis, 1995, p. 304). If we can accept that meaningful teaching involves "leading students beyond superficialities, through the adoption of appropriate teaching-learning activities" (Cox, 1997, p. 50), perhaps we require empirical research to address questions that are relevant for both classroom and real-world (Bednarz, 1997). And, research should make links between geographical literacy and vocational opportunities (Downs, 1994).

Indeed, over a decade ago it was identified that increasing connectedness of global communities through more efficient information technologies provides an opportunity to rethink our approaches to teaching geography (Nellis, 1995). However, an adjunct to increased access to technology in education is the increased need to demonstrate that such access provides demonstrably positive learning experiences at school (Shields, & Behrmann, 2000; Subrahmanyan, Krant, Greenfield & Gross, 2000). With regard to information and communications technologies (ICT) in education, there exists an, as yet limited, understanding of how computer based systems can best be designed to enhance learning (Murphy, 1997; Zandvliet & Fraser, 2004). While recognising the importance of collecting evidence related to the potential of computers to enhance learning, Murphy further demands systemic research which considers qualitative observation of how theories of learning can be used to design computer based learning environments which enable the intended types of learning to be achieved (p. 4).

In this regard, access to hardware and software and basic technical competence does not guarantee effective use of ICTs in the geography classroom. With respect to the development of graphicacy, Gerber (1995a) suggests that "the selection, generation, interpretation and use of graphics within geography classrooms involves many more complicated aspects… Selective cognitive decisions by the users of a graphic, in the form of spatial representations and sequences in learning, all impinge on the use of technology in geography lessons" (p. 52). Hence, understanding the cognitive processes inherent in the use of ICTs is necessary to inform technology decisions. Failure to comprehend fully these processes may lead to both decisions and curriculum that may not lead to the desired learning outcomes.

With reference to this dearth of research-based data, Downs (1994) asserts that "we must develop an inventory of the range and depth of geography skills and knowledge among students in order to offer a benchmark against which the impact of educational investments in geography can be measured" (p. 59). Further, by understanding emerging trends, geography can ensure that it encompasses instructional methods and experiences that meet the future needs of individual students and society generally.

Analyses of student conceptions of GIS will make a contribution to this benchmark. It will enable decisions to be made about whether GIS is a worthwhile investment. To do this requires that research related to GIS must reflect its application to practical problems and its role in geographical education (Nellis, 1995). A key area for research is identifying the most effective strategies for raising the level of students' conceptual understanding of what mapped data mean (Wiegand, 2003). By examining the process of map construction using GIS, for example, we can begin to uncover the extent to which students understand spatial relationships such as those found in maps (Bausmith and Leinhardt, 1998).

It is widely accepted that using geographical technologies might "enhance our ability to think spatially at the same time we prepare our students at all levels to live in an information-oriented society" (Fernald, 1996, p. 302). Similar views are offered by, among others, Dascombe (2006), Jenner (2006) and Kidman and Palmer (2006). West (1998a, 2003b) suggests the potential of GIS in modeling efficient thinking processes for students. Hence, research is required that considers student perceptions of places, patterns and processes under a range of instructional techniques (Bednarz, 1997). To this, Nellis (1995) specifies the need for research into the impact of GIS' use on learning in geography.

Following his study of GIS' impact on student attitudes, West (2003b) recommends qualitative appraisal of the development of student thinking skills while using GIS. However, there is no sense in examining the benefits of a tool that has at its base the promotion of interconnectedness of knowledge "by looking at its impact in small unconnected pieces that bypass the cognitive and networking uses of technology" (Sabelli, 2001, p. 3). How well geography education can exploit opportunities for technological inclusion depends on teacher understanding of conceptualisation afforded by it (Gerber, 1995a).

Personal Imperative

I am a teacher of geography. It is, therefore, incumbent upon me to internalise and act on this theoretical imperative. Indeed, to do so may not only benefit my students and me, but may offer a contribution to the subject itself. In this regard, Rawling (1997, pp. 11-13) highlights six curriculum challenges for geography and its educators:

1. confirmation of the distinctive nature of geography (e.g., subject matter, skills, approaches);
2. recognition of geography as an educational medium (ie, the wider contribution of geography to developing skills useful for society);
3. development of a public image of geography;
4. emphases on quality geography teaching and learning;
5. maintaining a strong professional base; and
6. commitment to an international community of geography educators.

Investigating what students think about GIS will enable me to contribute further to each of the above six challenges. Downs (1994) states that more geography teachers are needed to undertake relevant research within their career. As a teacher of geography, I want to know whether the instructional methods I employ and the resources that I use will enable students to successfully develop and demonstrate the learning outcomes that I intend. While my anecdotal experience suggests that GIS models for students the efficient encoding, management and manipulation of spatially referenced data (West, 2003b), the educational value in terms of what students are actually thinking while using GIS remains unclear.

Since quality teaching depends on quality research (Downs, 1994), it is incumbent on geography teachers to investigate areas of professional interest and significance. A declaration of the IGU is for geography teachers to not merely be specialists in geography, but also in geography education (IGU, 1997). Indeed, when reflecting over his ten years as editor of the *Journal of Geography*, Robert S. Bednarz wrote that "one of the goals that geography educators should establish for the next era is to conduct and publish research that will support geography education's continued progress" (Bednarz, 1997, p. 279).

Crabb (1995) believes that the quality of geography in secondary education is adversely affected by teachers following short-lived trends. Few would argue against the urgent need for research to ensure that GIS doesn't just become another, costly and resource intensive, trend. My role as a geography teacher has already involved extensive application of GIS in my own and other schools. I have quantitatively and qualitatively explored GIS' impacts and student conceptions of geography's role in their futures (see, for example, West, 1998b, 2003a, 2003b).

Burns (2000) provides a number of justifications for basing research projects on the everyday experiences of the researcher: it is easier to sustain motivation to complete research related to an area of personal interest; research projects based on everyday experiences may contribute to the researcher's own understanding of those experiences; and, by yielding worthwhile problems, investigating everyday experiences can lead to improved professional practice.

Further research of student conceptions of GIS will contribute to my own professionalism as a geography educator and the internationalisation of a geography curriculum that can withstand external scrutiny.

Deficiencies in Current Research

My first refereed article related to GIS' potential role in geography education was published in 1998 (West, 1998a). In it, I suggested that the dearth of research in GIS reflected the relatively recent interest of educators in it. However, in the nine years since, little progress has been made. This is not to say that only a few authors have considered its possible impacts. Rather, there has been widespread communication about the potential of GIS in education. There has simply been little empirical research undertaken on this topic, as noted by Baker and Bednarz (2003).

Literature related to this topic is drawn from a range of fields related to geography education. However, global data suggest that geography has not embraced as many contemporary educational directions as it could have (Gerber, 2001). In 1994, Downs claimed that research current at that time was "largely incidental and therefore peripheral" to actual geography education (Downs, 1994, p. 58). In a recent reflection on Downs' lament, Baker and Bednarz (2003) suggested that "this call remains relevant, pressing, and still unmet" (p. 231).

In 2006, I edited a **Forum section** on issues affecting the uptake of GIS in Australian and New Zealand schools for *International Research in Geographical and Environmental Education*. The message from its contributing authors was not new. For example, three years earlier, in 2003, the *Journal of Geography* published an edition focusing on Research on GIS in Education. Its editors noted how frequently the merits and barriers of including GIS in the classroom have been identified since the (US) First National Conference of the Educational Application of Geographic Information Systems in 1994 (Baker and Bednarz, 2003). They also observe that despite widespread promotion of its use, GIS technologies remained peripheral to most geography education. One reason, they claim, is the "paucity of research on its effectiveness in promoting significant learning" (p. 232). Specifically mentioned was what they perceived to be inadequate knowledge of the potential impacts of GIS on such things as spatial cognition, knowledge acquisition and process skills. To this, they highlight the "need for teachers to have a clearer understanding of student's cognitive processes, misconceptions, and ability to make meaning from learning experiences using GIS" (p. 232).

Deficiencies in research about GIS' role in geography education revolve around two main issues. First, the absence of sufficient substantive research on the topic (Baker & Bednarz, 2003). Second, the apparent emphasis on reproducible projects that constrain the questions that researchers have chosen to ask and answer. Gritzner (2003) supports this, adding that the results of such analyses may not "inform classroom instructors about how…people acquire spatial knowledge and skill in real world environments" (p. 279).

According to Harman (2003), geography research must have an applied value if it is to be justifiable. This research was described by Downs (1994, p. 57) as "sadly lacking" and remains so a decade later. Perhaps unfortunately, there is not a single empirical study that categorically answers the question of whether GIS should be used in schools. Rather, a raft of impacts of GIS in education has been observed and these relate to several themes: student/teacher attitudes, motivation, geographic and cartographic knowledge. To a lesser extent, data suggest a role in the processing of spatial information. Most research has quantitatively emphasised the so-called middle years of schooling, within a United States and British context. Design has largely been limited by external curriculum constraints and the need for replicability. Most authors undertaking GIS research to date have identified limitations in their own research designs and the need for a greater awareness of GIS' role in education. This is a need that is best balanced with the need for research based upon appropriate methodologies, such that the data obtained may "be analysed in ways that will stand up to significant scrutiny" (Baker and Bednarz, 2003, p. 233). Indeed, in her recent evaluation of the potential educational implications of GIS' use in school geographies, Sarah Witham Bednarz (2004, p. 191) observed that:

> the geography and environmental education research community do not know the exact contribution of GIS to substantive geographic and environmental learning. Nor are we able to state unequivocally that GIS in elementary and secondary education has a clear, positive effect on the ... central goals of geography and environmental education.

In short, we do not yet know where, if anywhere, GIS belongs in the geography curriculum. On the basis of this argument, attention now turns to the nature of the present investigation.

Central Phenomenon and Research Questions

The central phenomenon of the present study is student conceptions of GIS. The specific research question being investigated is:

> *What are the conceptions of geographic information systems (GIS) held by Senior Geography students?*

The answers to this question will contribute to:

1. Knowledge of the spatial understandings held by students of geography;
2. Understanding how students gain an understanding of spatial phenomena of varying levels of complexity;
3. Awareness of the potential educational outcomes associated with using GIS;
4. Current discussions about the merit of using ICTs in education, with specific emphasis on the use of GIS in geography education;
5. Decisions related to current and potential geography curricula; and
6. Understanding how the subject Geography is and can better be understood.

Study Design

Methodology

The need for qualitative research is argued by Bruhn (1989), who asserts the need to "develop more explicit and systematic methodologies which refer to language and communication as the central categories of analysis". Dahlin (1994) further argues for such methodologies, adding that "theoretical reflections on the nature of conceptions [possess] an epistemological character". More specific to the present research, Gerber (1993) notes that qualitative research methods are a well-established form of research in social sciences, *offering potential for geography educators* (emphasis added).

Phenomenography is one qualitative research specialisation. Phenomenographic research approaches developed in the late 1970s and early 1980s (Bruce, 1995). While it does not appear to "reconcile the search for authentic understanding with the search for scientific rigour" (Richardson, 1999, p. 53), it is a research methodology that has presented a number of benefits.

In 1995, Gerber (1995b) suggested that phenomenographic research has yielded results that offer alternative descriptions of people's conceptions of a range of phenomena. The value of the phenomenographic methodology in educational and social science research has also been discussed by several authors (see, for example, Bruce, 1995; Dahlin, 1994; Irvine, 2005; Mailler, 2006; Nagel, 2005; Pramling, 1995).

Methodologically, phenomenography relies upon the discursive accounts of participants (Richardson, 1999). This reflects the view that language is a "device for representing the world" (Ekeblad, 1995). Although more than a decade ago, Gerber perhaps best captured the foundation of phenomenography when he stated that people's experiences of phenomena "are recorded in the words of other experiences by the participants in a specific context" (Gerber, 1992b). Because of this, interview transcripts can be analysed to detect the "qualitatively different variations in the [interviewees'] experiences" (Gerber, 1995b).

Bruhn (1989) suggests that this qualitative analysis of data as discourse may, in many ways, serve the functions traditionally performed by statistics in quantitative analyses. Discourse analysis allows the variation in experiences of the participants to be revealed, which, Gerber (1995b) claims, enables this methodology to "adopt a supra-individual orientation in the investigation of human experience" (p. 1). Gerber continues to clarify the objective of phenomenographic research as being "human experience as it is remembered from a second-order perspective" (p. 1). Moreover, by emphasising the relationships between subject and object within a specific context, he argues that phenomenography offers a distinctive relational nature (p. 1). In this regard, phenomenography fundamentally "accepts that people develop their knowledge of the world through personal experience…all knowledge is subjective in nature" (Gerber, 1992b).

The Role of Phenomenography in Educational Research

The issue of context is important in educational research (Ekeblad and Bond, 1995). Ekeblad and Bond continue to suggest that processes of learning are not always internal and mental but, rather, they "unfold in interaction with the world around us". Within phenomenographic research, the form of knowledge of the world around us is represented through conceptions (Dahlin, 1994). Hence, within educational research, phenomenography can inform pedagogical decisions to effect conceptual changes by the learner in a particular context (Bowden, 1990).

Two decades ago, Dahlgren (1984) stated that "student learning outcomes vary in terms of their understanding of the phenomena being studied". An adjunct to this is that an understanding of student conceptions of phenomena may influence those outcomes. Gerber (1992b) more recently noted that variations in the phenomenographic approach may be used in geography education research, such as to investigate different conceptions that learners hold of different concepts; to consider the types of learning that occur in the classroom; and, to investigate the processes that learners use. For the present study, phenomenography can be used to gain an understanding of student conceptions of GIS; and, therefore, provide some indication of the extent to which its use enables educational outcomes to be achieved.

Although GIS' technical potential and educational application have evolved since the early 1990s, it was even then that Gerber and Boulton-Lewis noted that graphically represented data, generally, are very complex (Gerber, 1992a). Developing an understanding of such data representations is equally complex.

As such, these authors claim, teachers need to understand this process if they wish to support student learning. The proposed research responds to this call by investigating student experiences of using graphic representations, as depicted by GIS.

Sampling and Data Collection

The research question is investigated using an opportunistic sample of 109 Year 11 and Year 12 students from four metropolitan and regional schools in south east and north Queensland, Australia. All participants are enrolled in courses of Senior Geography that incorporate a GIS component. The investigation proceeds as follows:

1. Students are interviewed to explore their conceptions of GIS
2. Interviews are transcribed and their text analysed to identify Categories of Description
3. Conceptions are distilled from within these Categories of Description
4. Categories of description are modelled to determine an Outcome Space, representing the relationships between the conceptions

Specific details related to each of these stages will be included in Chapter Three.

Structure of the Thesis

Chapter One has contextualised the research. The research problem has been outlined: will using GIS within the geography classroom contribute to students' geographical education. The specific research question being investigated in this study is: what are the conceptions of GIS held by Senior Geography students?

Chapter Two critically evaluates the literature related to three aspects of this research. First, it evaluates geographical education, generally, and its potential contribution within the Queensland curriculum, specifically. Second, it evaluates the potential role of GIS in contributing to a geographical education. Finally, Chapter Two culminates in an overview of: questions that arise from the literature; and, the central phenomenon and research question specific to this thesis.

The methods and design of research that address the research question is then introduced in Chapter Three. Chapter Three also describes the characteristics of participants, their schools, communities and the place of GIS within the Senior Geography curricula within their schools.

In Chapter Four, the conceptions of GIS are distilled from within categories of description. Chapter Four concludes with the emergence of an outcome space that delineates the interrelationships between the conceptions.

Chapter Five concludes the thesis by: positioning the research findings within the context of the reviewed literature; evaluating the implications of the findings for Queensland Senior Geography in particular, and geographical education in general; reviewing the investigative method to identify its limitations; and, by recommending future research. References and Appendices follow Chapter Five.

CHAPTER TWO

REVIEW OF LITERATURE

"As society has evolved, so has the use of geographical information" (Miller et al., 2005, p. 258).

Introduction

With respect to the (1974) recommendations made by UNESCO, geography education makes a tremendous contribution to international education (IGU, 1997). This international nature of geography's contribution is in itself an example of geography's broad reach across scales of study. To this, Gritzner (2003) adds that "every day of our lives, we live geography" (p. 90).

Naish *et al.* (1987) stipulate that the inclusion of any subject in a school's curriculum should be justified through elucidation of not only the body of knowledge with which it is concerned, but also its potential for development of broader capabilities for participation in the world. The manner by which this knowledge can be learned and capabilities developed thus becomes integral to the effective 'teaching' of that subject (Gregg *et al.*, 1997).

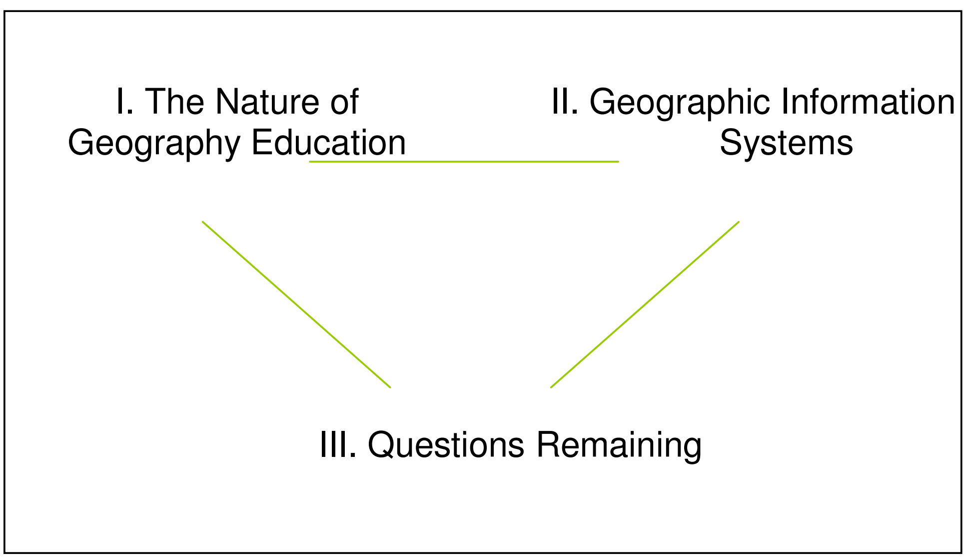


Figure 1. Three foci of Chapter Two.

In this regard, it is important to determine whether the nature of geography is such that its place in the curriculum is justifiable. This constitutes the first of three foci elucidated by this chapter (Figure 1). Specifically, this chapter reviews the literature to argue that Geography:

- is concerned with a multidisciplinary body of knowledge of global significance;
- emphasises a range of technical and problem-solving skills; and,
- encourages its students to develop capabilities to participate actively in the world about which they are learning.

If geography and a geographical education can be shown to be valuable, then the way it is taught requires consideration. Once this has been ascertained, the chapter will move to evaluate published findings about classroom practices and the extent to which they afford teachers confidence that students are learning what is intended. This discussion will emphasise seven elements of a geography education (Figure 2).

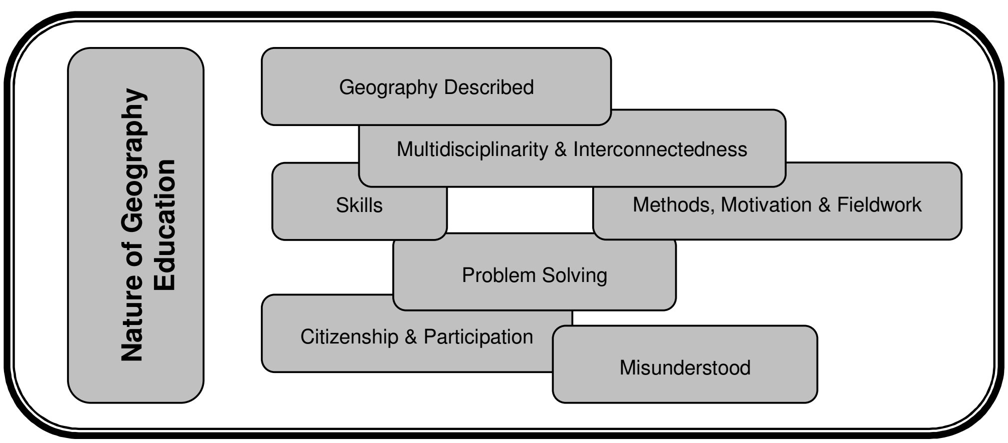


Figure 2. Seven elements of discussion about The Nature of Geography.

Associated with the discussion of teaching methods in geography is the chapter's second focus: investigating the role of Geographic Information Systems in contributing to geographical education. This discussion will emphasise four elements (Figure 3).

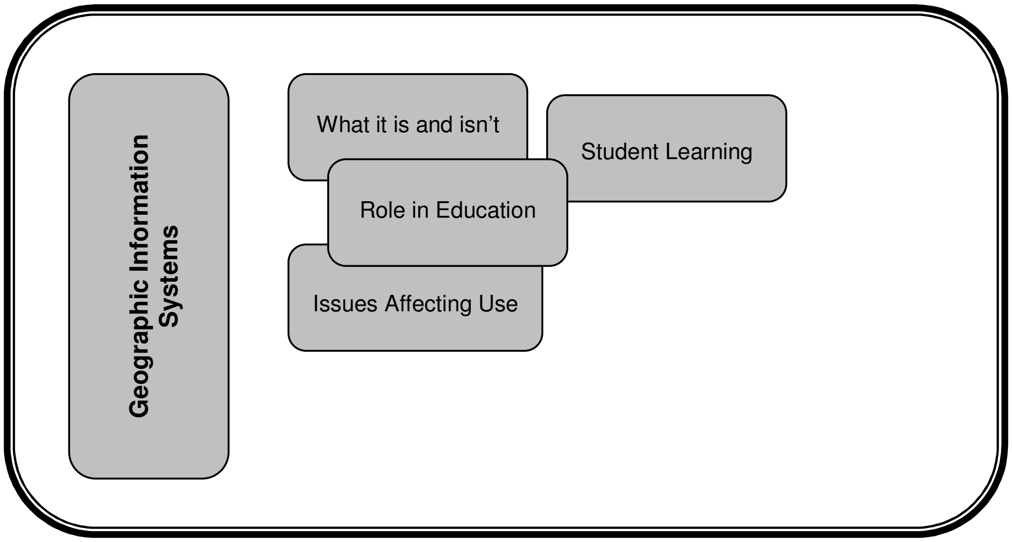


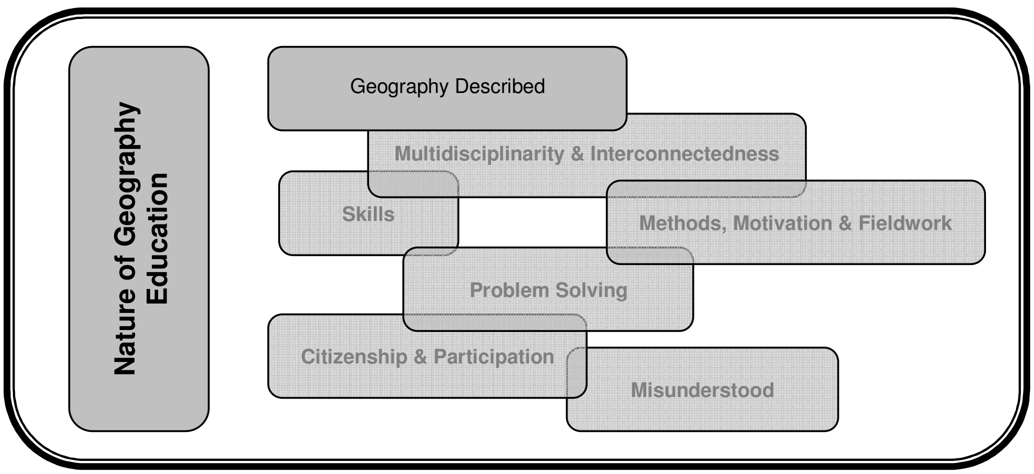
Figure 3. Elements of discussion about Geographical Information Systems.

Emerging from the review of Focus I and Focus II will be the chapter's final focus: questions that indicate potential for further research. These questions will be revised to identify a central phenomenon and research question for this project.

The Nature of Geography Education

Focus I, The Nature of Geography Education, will be explored through investigation of seven elements (Figure 2).

Geography Described



Geography as a discipline is defined at once by its spatial emphases and its reliance upon methodology more so than its content. More specifically, Fernald (2002) states that geography is "the analysis of the areal distribution of a phenomenon [that involves the examination of] the location and distribution of phenomena in space, or place, by means of identifying their density, pattern, diffusion, and dispersion" (p. 126). He continues that geography is "the unique discipline that examines the earth from the spatial point of view" (p. 127).

Because the features that represent the focus of geographical study are dispersed across the surface of the earth, the study of geography encompasses a great deal of interconnectivity. In this regard, its study is about how local, national and international scales interact (Rawling, 2000). Three years earlier, Stoltman (1997) cited the International Charter on Geographical Education which asserts that "geography is the science which seeks to explain the character of places and the distribution of people, features and events as they occur and develop over the surface of the earth" (p. 33). According to Fernald (1996), geography is involved with two sets of spatial activities: location and distribution, and interaction and relationships. The US definition (Geography Education Standards Project, 1994) provides further detail still, delineating geography as

> an integrative discipline that brings together the physical and human dimensions of the world in the study of people, places and environments. Its subject matter is Earth's surface and the processes that shape it, the relationships between people and environments, and the connections between people and places (p. 18).

To this, the Australian Geography Teachers' Association adds that geography "involves how people in certain situations may be influenced by environmental circumstances … [and] … the way that people have sought to control physical and social environments" (Gerber, 1997, p. 38).

Evident from the above summary of geography's definition is that its unifying element is the spatial context. This context is explored further by Dale (1995), Murphy, Morrisson and Conolly (2001), Rawling (1997) and Tamagno (2000). Earlier than most others, Fernald (1996) articulated succinctly this commonality with the claim that geography "utilises the spatial approach to the understanding and analysis of Earth as the home of humans" (p. 3). Within this, Gerber (1997) recognises that geography's many definitions possess four common elements: location, pattern, distribution and land-people interaction. The study of these four elements within geography usually involves a regional emphasis, where a region is delineated through classifying spatially arranged features as similar or dissimilar (Gritzner, 2003).

Rawling (1997) also notes that a distinctive feature of geography is its emphasis on understanding skills, its relevance to real-world issues at a variety of scales and its contribution to the development of vocational skills. Through these skills, geography provides the framework for making sense of the spatial data that we encounter in our daily lives (Conolly, 2000; Salter, 1995), and which form the basis of the subject's content. More simply, to the geographically illiterate, places are meaningless (Gritzner, 2003).

Geography's value extends beyond itself. This is because most variables in both the sciences and the humanities have a spatial context (Oldakowski, 2001). By emphasising this spatial perspective, geographers can describe, and therefore seek to explain patterns that are evident within human-natural environments (Conolly, 2000; International Charter on Geographical Education, 1992; Tamagno, 2000). Consequently, "geography occupies a distinctive place in the world of learning, offering an integrated study of the complex reciprocal relationships between human societies and the non-human components of the world" (Quality Assurance Agency, 1999). This crossing of the cultural-physical divide is essential to an understanding of geography's potential (Healey *et al.*, 2000); an understanding that will come through "the determination to grapple with the complexities of human-environmental interactions in small communities, within nation states and at a global scale" (Young, 1995, p. 7).

Geography is also a reflective discipline (Healey *et al.*, 2000). Many definitions of geography include reference to its contribution to the development of a futures perspective (Fitzpatrick, 2001; Gritzner, 2003; Howitt, 2002). Gritzner (2002, p. 240) states that "Geography is the study of what is where, why there and why care?" Similarly, Fitzpatrick (2001) classifies geography as a discipline characterised by three questions: 'What's where?', 'Why is it there?' and 'So what?' Howitt (2002) echoes the first two of these three questions, stating that geography teaches us where we are and why we are here. By comparison with the previous two authors, Howitt also clarifies the reflective nature of the third question by arguing that geography also teaches us what we might become.

This reflective nature of geography is developed through its adherence to four basic steps (Casinader and Casinader, 1994):

1. collection of primary and secondary data;
2. identification of trends and patterns;
3. analysis to determine reasons for the trends and patterns; and,
4. evaluation of the importance of these reasons.

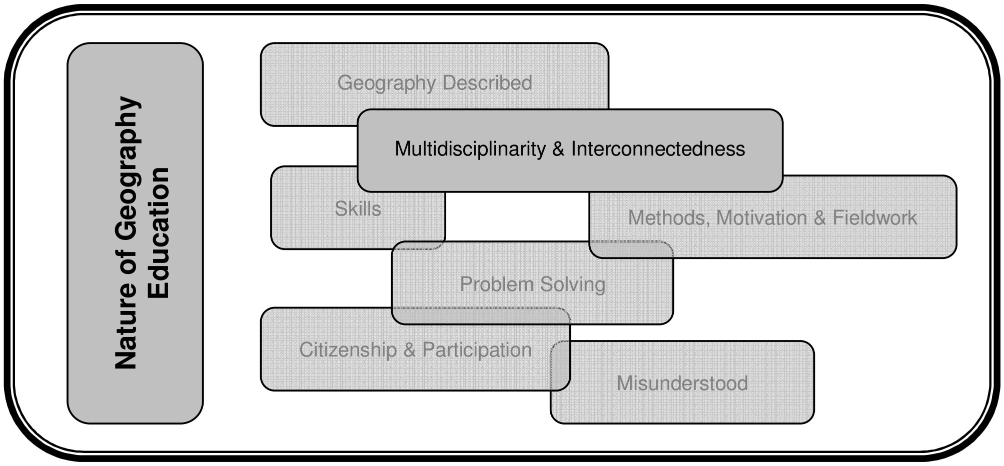
With respect to the final, evaluative, step, Casinader and Casinader (1994) continue that this process enables "students to create their own set of future situation characteristics by extrapolating from what they know" (p. 42). Evaluation is also one of the five thinking skills integral to thinking geographically (Catling, 2003); its integral nature is evidenced by its inclusion in secondary geography curricula around Australia (Casinader and Casinader, 1994).

Beyond the investigation and evaluation of spatial information, the role of geography is widely lauded as considerable. Indeed, Gritzner (2003) observes that most Western urban-industrial world countries have placed geography at the core of social-science curriculum. The US Geography Education Standards Project (de Souza and Downs, 1994) cites four reasons for the study of geography: existential (to help us understand where we are); ethical (to provide us a basis for cooperation to ensure sustainable futures); intellectual (to enhance decisions by creating better informed citizens); practical (to respond to increasing global interconnectedness by increasing the knowledge and skill that is needed to solve these issues). Similarly, Marran (2003, pp. 42-43) offers five reasons for the continued existence of geography education:

1. it provides a spatial perspective that is not provided in any other discipline;
2. it describes and seeks to explain changing patterns;
3. it is "eminently useful" – emphasising problem-solving in real-world contexts;
4. it provides an effective context for life-long learning; and,
5. it provides an opportunity to develop a perspective of the world from both scientific and humanistic viewpoints.

This chapter has, thus far, described what geography is. With respect to this, the remainder of this section will argue for its inclusion in school curriculum, by examining what its students are both exposed to and engaged in.

Geography: its multidisciplinarity and interconnectedness



In terms of its contribution to education, and regardless of its name, geography essentially provides "a socially critical classroom pedagogy" (Rawling, 2000, p. 210). This is achieved through its emphases upon both interdisciplinarity and diversity (Healey *et al.*, 2000). According to the International Geographic Union, geography is unique for three reasons, the first of which is its synthesis of other, science and humanity, disciplines (Stoltman, 1997). This is also discussed by de Souza and Downs (1994), Healey *et al.* (2000), Murphy *et al.,* (2001), Oldakowski (2001) and Young (1995).

Healey *et al.* (2000) provide a particularly lengthy discussion about this. Since all disciplines seek to explain some aspect of our existence, all disciplines must be, in some way at least, connected. The connections are explored through disciplinary specialisation. In this manner, each discipline provides a small contribution to a collective understanding of a greater picture. Healey *et al.* (2000) conclude that "the nature of geography means that geographers are used to borrowing and adapting ideas from outside their discipline" (p. 5).

Indeed, some would argue that geography is the most converging of all school subjects (Marran, 2003). He argues that this is because it joins together aspects of all other subjects to enable a coherent understanding of "the causes, effects, and meanings of the physical and human events that occur across the Earth's surface" (p. 43). By using the ideas and methods of many, traditionally discrete, disciplines, geographers can synthesise knowledge in an holistic sense; as a discipline it possesses "sensitivity and understanding needed to work with people of other disciplines" (Young, 1995, p. 7), enabling it to assist other disciplines in their own attempts at increased understanding of phenomena (Murphy *et al.*, 2001, p. 42). By corollary, Gritzner (2003) asserts that geographical illiteracy precludes an understanding of the interconnectedness of global phenomena.

The convergent nature of geography is evident in Queensland, where the Senior Geography syllabus arguably encompasses more disciplines than any other subject offering in Queensland. Furthermore, of the 49 Common Curriculum Elements (CCEs) derived from Queensland senior syllabuses and assessed as part of the Core Skills Test to determine university entrance ranking, 38 are present in Senior Geography, compared with the average of 27.8. Indeed, the number of CCEs addressed within Queensland Studies Authority (QSA) accredited Senior Geography is third only to Mathematics A (42) and Earth Science (41). By way of comparison, the least frequent occurrences occur in Secretarial Studies (12), Graphics (15), and Agriculture and Animal Production (17) (Queensland, 2002).

This multidisciplinarity affords Geography with a valuably diverse body of knowledge. "In a positive sense … diversity gives geography part of its creative tension and capacity for change and renewal" (Slater, 1995, p. 4). Stoltman (1997) makes the additional claim that secondary geography education should increasingly emphasise interconnectivity. Nellis (1995) suggests that making such connections between phenomena studied at a local scale and the global processes of which they are a part is a valuable means of achieving this interconnectivity. Further, Murphy *et al.,* (2001) state that being able to recognise these links and relationships is a precursor to deep understanding.

Accordingly, Geography's "wide-ranging content" enables many opportunities for the study of issues at a range of scales (Rawling, 2000, p. 210). The breadth of geography's study is the third reason for its uniqueness (IGU, 1997). In Queensland, Senior Geography involves the study of Core and Elective topics, at a range of Scales of Study and grouped within four Themes (Table 1). Syllabus page 13 outlines the requirements for core and elective units, as follows (Queensland, 1999a, p. 13).

Core units as outlined in the syllabus

> *provide a framework for schools to select appropriate topics and case studies, to match the interests of their students, the availability of resources, and local conditions. The key questions [for the core units] … are not statements of content. They provide guidance for the selection of case studies at a depth sufficient to allow students to explore the unit.*

At least three elective units must be studied, with at least one studied in each of three semesters. Each elective must relate to the theme being studied in the semester in which it is offered.

> *The selection of elective units may be made as a response to the interests of students and teachers as well as on the basis of the resources to which the school has access. The elective topics may be used to introduce a theme, to link core topics within a theme, to provide opportunities for the examination at greater depth of aspects of the theme or to conclude a theme. The topic for the elective may arise from an area of interest developed in a core unit and explored to a greater degree in an elective unit.*
>
> *Core and elective units are not distinguished in level of importance, and therefore may be studied over similar time frames within a theme… [S]chools may tailor their courses to meet the needs and interests of their students and the resources of their schools.*

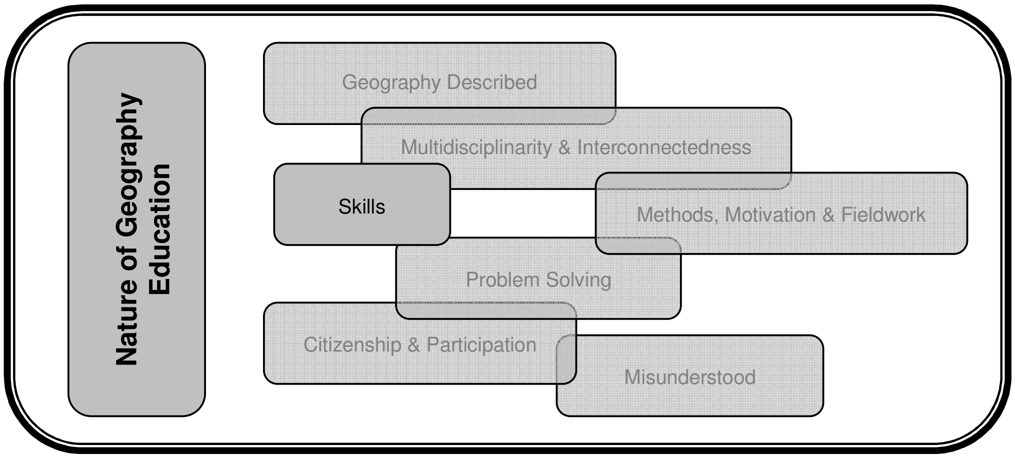
Table 1

Themes, Topics and Scales of Study prescribed by the 1999 Queensland Senior Geography Syllabus (Queensland, 1999a).

This table is not available online.
Please consult the hardcopy thesis
available from the QUT Library

However, it must also be noted that, despite the stated benefits, Geography's diverse and interdisciplinary nature can confuse students (Healey *et al.*, 2000). For this reason, it is important that the methodological basis of school geography be developed to enable active student engagement with a range of different discourses, within which there exists "the babble of technical terms and nuances of technical language" (p. 4). The argument here is that if geographical education emphasises appropriate skills, this confusion may be obviated.

Geography and its skills



The second reason for geography's disciplinary uniqueness is its emphasis on methodology. Its definition more by method than by content is discussed by Gritzner (2002), and Fernald (1996, 2002). Success in geography education requires a combination of: geographical knowledge; cognitive skills related to that knowledge; fieldwork as the basis for learning; and, the use of maps (Gerber, 2001). Geography education is increasingly emphasising thinking skills, rather than simply requiring place-name knowledge (Gerber, 2001; Gregg *et al.*, 1997). Indeed, Gerber (2006) also reminds us that there is not a "unified set of knowledge [and] skills that underpin international geographical education" (p. 15). For example, in Queensland's Senior Geography syllabus, knowledge constitutes only part of one criterion in which students are assessed. As exemplified in Table 2, the recall of spatial information forms part of the definition for Criterion One: Knowledge and Understanding.

Table 2

Assessment criteria associated with Queensland Senior Geography syllabus (Queensland, 1999a).

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Please consult the hardcopy thesis
available from the QUT Library

Teaching that develops geographical thinking allows students to draw generalisations from data analysis (induction) and test generalisations using those data (deduction) (Fernald, 1996). To elaborate, Fernald (1996) suggests that thinking geographically "implies activities and thinking that examine and analyse aspects of spatial distribution; some of these aspects are the density, pattern, diffusion and dispersion of phenomena in place" (p. 3). Two benefits come from emphasising the spatial organisation and distribution of phenomena (Oldakowski, 2001). First, since people possess differing understandings of abstract concepts, spatial awareness helps to provide a uniform perspective. Second, understanding the spatial perspective is necessary to understand more complex concepts and to utilise geographical technologies, such as GIS. With respect to the latter, Gerber (1997) observed that being able to think like a geographer means being able to use its tools. In the current discussion, however, geography's tools include both the technologies and the cognitive processes that enable its efficient study.

Despite the role of its skills in underpinning effective geographical enterprise, Gerber's (2001) global survey of geographical educators from 32 countries revealed that practical tasks and skills were not rated highly by respondents in terms of their perceived value in lower secondary school. In this survey, by way of comparison, facts and concepts were rated as highly valuable. Yet, in practice, doing geography involves participation in a process; a methodology that has as its basis the observation of people, places and the environment to better understand and appreciate their interactivity (Gerber, 1997).

In support of the value of skills-based geography education, Healey *et al.* (2000) believe that geography students should be given good exposure not only to a broad liberal education, but to skills of communication, analysis, information technology, numeracy, literacy and problem-solving. In this regard, the Queensland Senior Geography syllabus states that, through studying Geography, students will "become proficient in the use of a range of thinking, social, communication, practical and study skills…as they seek an understanding of people-environment relationships and the kinds of knowledge and patterns that relate to them" (Queensland, 1999a, p. 5).

Geography's contribution to the development of communication skills extends to encompass a wide range of forms (de Souza and Downs, 1994). This range is arguably wider in geography than in any other subject (Murphy *et al.*, 2001). One such form is communication using visual forms.

As early as, 1995, visual communication was gaining widespread acceptance as a viable alternative to traditional emphases on written and spoken forms (Gerber, 1995a). If we can accept that the role of graphic representation is increasing in what is often described as our technologically dependent society**,** then we may conclude that its prominence in Senior Geography increases the potential role of this subject in preparing students for participation in an increasingly visual society (Yates, 2000). Gerber (1995a) and Catling (2003) provide further discussion of this.

To understand the value of Geography in developing student capacity in this regard, we should first identify the elements of graphical thinking. Graphical thinking uses images instead of letters and numbers, even though letters and numbers are usually a part of the images being used (Catling, 2003). Thinking graphically is a construct of five other thinking skills: information processing skills (e.g., reading a map); reasoning skills (e.g., drawing a sketch map to show specific features in a relationship); inquiry skills (e.g., selecting resources to gather information to answer specific questions); creative-thinking skills (e.g., creating a model to show the impact of a proposed urban development); and, evaluation skills (e.g., generating options and then selecting a solution for a particular issue) (Catling, 2003). On this basis, it could be argued that thinking geographically is synonymous with thinking graphically.

The visual images commonly used in geography can be broadly grouped into three categories (Catling, 2003). *Photographs* can be used to stimulate questions for inquiry, visualise key elements of a place and represent and examine images of a place. *Sketches, diagrams and charts* can be used to create diagrams that show sequences of events, record observations from a model and display fieldwork processes and findings. Finally, *maps* can be used to think about an appropriate course of action (e.g., determine the most efficient route), create an understanding of space (e.g., plan a suburban development) and investigate, record and analyse processes arising from human-environmental interactions (e.g., distribution of income, bushfire risk). Table 3 classifies the visual images included within the Queensland Senior Geography syllabus according to these three classes.

Table 3
Visual images of the Queensland Senior Geography Syllabus (Queensland, 1999a), classified according to Catling's (2003) nomenclature.

This table is not available online.
Please consult the hardcopy thesis
available from the QUT Library

The syllabus also includes reference to tables of data, observation schedules, audiovisual and computer presentations (Queensland, 1999a).

However, and despite their importance, "opportunities provided by visual images in the geography classroom are not always fully exploited by teachers to enhance geographical knowledge, understanding and skill development" (Yates, 2000, p. 68). To ensure that images are used profitably in geography teaching, Roberts (1998) offers four principles to guide their use. First, the image should be a part of a larger program of inquiry, not as an extra. Second, the image should be selected on the basis of how it can contribute to the inquiry. Third, students should be encouraged to see images "as selections from reality". Finally, an image should provide opportunities for students to think about and ask questions about what they see.

Of the three categories of visual images, maps are widely considered to be the geographer's most fundamental tool (Catling, 2003). A map represents the features of a place "more succinctly (if not more accurately) than words could" (p. 39). This is evidenced through the link between map use and understanding, as investigated in a range of geographical education contexts. One such study, by Oldakowski (2001), quantitatively investigated the influence of map construction on the attainment of undergraduate university students with no prior tertiary geography experience. This study concluded that students who participated in the creation and analysis of thematic (choropleth) maps had a statistically significant "better understanding of the spatial perspective" than those students who were not exposed to learning experiences that "placed special emphasis on important concepts such as spatial organisation or spatial distribution" (p. 249).

Similarly, quantitative and qualitative investigation of 7th grade students exposed to two different instructional strategies concluded that students who were actively involved in constructing and working with maps provided statistically significant improvements in accuracy when developing mental maps of the world (Chiodo, 1997). However, study of the types of questions that 5th and 7th grade students ask and answer about maps revealed no statistically significant benefits from more frequent use of maps (Gregg, 1997). Despite the absence of statistically significant benefits, subsequent qualitative study of these students did reveal that their abilities to obtain information from maps (in the visual-spatial mode) and then accurately ask or answer a question (in the verbal mode) "almost certainly required them to enter deeply into the processes of reading and interpreting maps" (p. 255).

To this end, Gregg suggests that obtaining information from a map involves three distinct processes. First, map reading identifies explicit features on a map. Second, map interpreting somehow integrates two or more pieces of information from the map, identifying spatial relationships/patterns that are not "explicitly labelled" (p. 251). This process involves the "visual chunking of information into meaningful patterns" to create new meanings from the map's explicit features. Third, and most cognitively demanding, making a map inference relates one or more elements from the map to some prior or other knowledge, that has not also been read nor interpreted from the map. Making a map inference allows the student to draw conclusions about specific features of the map; conclusions that are ill-substantiated when solely using the information provided in the map.

"WHAT is WHERE, why THERE, and WHY CARE?"

"WHAT is	WHERE,	why THERE,	and WHY CARE?"
[Phenomenological]	[Spatial]	[Analytical]	[Implicational]
All features of Earth's surface that occur in spatial distribution *Physical features* (Nature) *Human features* (Culture)	Location Site *(Specific)* Situation *(Relative)* Distribution Pattern Area Region Accessibility Remoteness	Agents Processes Interrelationships	Importance Relevance Action/Reaction
(DESCRIPTIVE)		(CONCEPTUAL)	
PLACE	*LOCATION* *REGION*	*INTERACTION* *MOVEMENT*	

Figure 4. Defining geography (after Gritzner, 2002).

It is within maps that the spatial emphases of geography are most evident and it is with the use of maps that geography students can develop spatial awareness (Oldakowski, 2001). This is discussed further by Gerber (1992a), Mosenthal and Kirsch (1990), Rittschoff and Kulhavy (1998), Schulze (1996), Thompson (1999) and Trifinoff (1995). While visual images (including maps) are "a vehicle for differentiation" and support evaluative processes (Yates, 2000, p. 69), making map inferences first requires students to be able to analyse the world as it is represented in maps (Casinader and Casinader, 1994).

To help students do this, and since "the spatial method of organisation and analysis is geography's most essential element" (Gritzner, 2002, p. 39), it is important to ensure that they first understand the "building blocks" of spatial awareness: the data (Oldakowski, 2001, p. 249). For Gritzner (2002, 39), this understanding was supported by an illustration of the spatial detail associated with the four elements of his own definition of geography: WHAT is WHERE, why THERE, and WHY CARE? (Figure 4).

One example of the importance of emphasising these building blocks in school geography is in the notion of Key Geographic Ideas (KGIs) adopted in the Victorian geography curricula. An understanding of the KGIs is integral to a student's understanding of senior geography, and not only in Victoria (Cranby, 2002). KGIs can be loosely categorised as lower-order and higher-order, depending upon their level of cognitive complexity (Tamagno, 2000; Figure 3). Student understanding of them can be demonstrated in two main ways: by identifying where a particular Idea is evident in data; and, by describing data by identifying where/how a particular Idea is evident in those data (Cranby, 2002).

Of the KGIs, spatial association is considered one of the most difficult. By definition, it is "the degree to which two phenomena are similarly arranged or located in space" (Cranby, 2002, p. 25). To support the development of spatial association, and through it geographical literacy**,** Oldakowski (2001) advocates that students be taught about the different classes of data and the influence that different methods of class construction have on thematic maps. Murphy *et al.* (2001) also consider the geography teacher responsible for giving students the knowledge and skills to use data to develop an understanding of places and people. Yet, this need not be a burdensome task, because most geography lessons encompass one or a few geographic methods of analysis (Fernald, 2002), that reflect some, but rarely all, KGIs. By focusing on data and their many forms, students are allowed to investigate a wide range of phenomena, quite possibly reflecting their own interests (Oldakowski, 2001). Furthermore, using visual imagery, rather than emphasising text, allows lower achieving students for whom literacy is not a strength to also experience some success (Yates, 2000).

Hence, by focusing on graphical thinking within geography education, students can learn to construct their own geographical knowledge based on images (including maps); and, they can do this with teacher assistance rather than teacher direction (Yates, 2000). By engaging students in actively looking at maps to generate their own questions, geography educators will influence students' subsequent use of those and other maps (Gregg, 1997). In turn, this will assist students to learn how to select and use a range of data to answer the questions posed by both themselves and others (Yates, 2000).

This process of selecting and eliminating information (that is seen to be relevant to the question posed) is a transformation process which can lead to new configurations of knowledge (Gregg, 1997). Indeed, the concept of region is arguably based upon spatially sorting features into similar and dissimilar places (Gritzner, 2003). This is one way of providing "a context that promotes flexible, generative use of information within a content area by creating new connections among the pieces of content" (Gregg, 1997, p. 251). Specifically, when considering the range of topics and scales studied by Queensland's Senior Geography students, it is possible to understand why McKeown-Ice (1994, p. 40) believes that non-geographers are rarely aware of the "vast" potential offered through examination of spatial patterns at various scales. In general terms, it is by emphasising such interconnectivity that geography makes a contribution to the development of life long learners (Gerber, 1997).

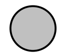
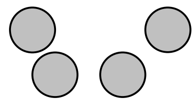
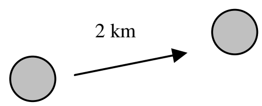
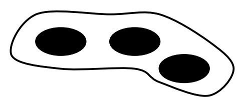
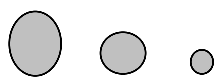
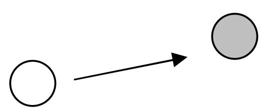
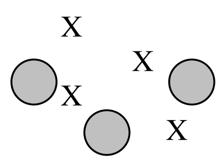
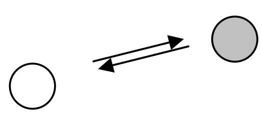
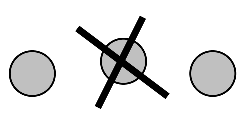
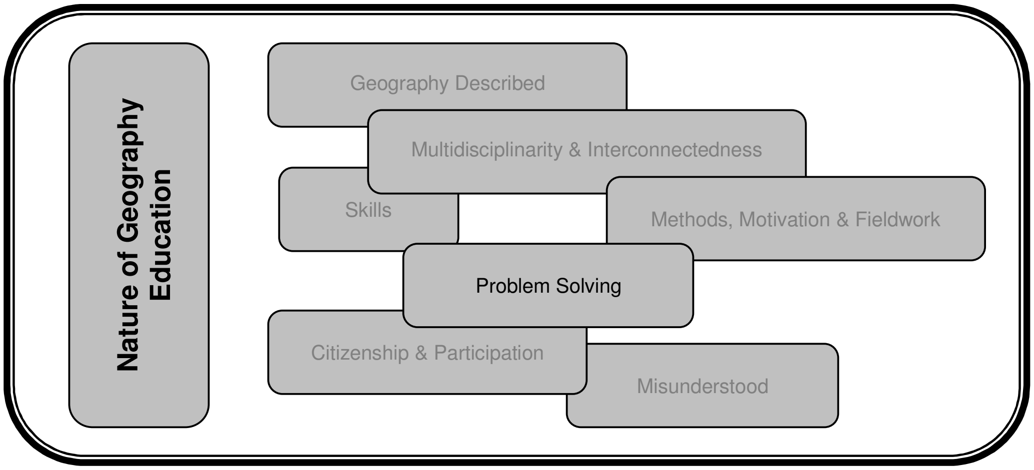
	KGI	Symbol	Definition
Lower-Order	Location		Is where something occurs on the surface of the Earth.
	Distribution		Is the arrangement of things at, or near, the Earth's surface across many locations.
	Distance		Is the space between things including places, events, people and ideas – measured in kilometres, cost or time.
	Region		Is a definable area with one or more common characteristics which makes it different from the surrounding area(s).
	Scale		Is the level of representation of reality – global, regional or local scales.
Higher-Order	Movement		Is the change in the location of a thing resulting from the use of energy.
	Spatial Association		Is the degree to which things are similarly arranged over Earth space.
	Spatial Interaction		Is the nature of linkages between things and the degree to which they influence each other over space. People and their environments interact in a definable location or region.
	Spatial Change Through Time		Is the change in the location, distribution or frequency of things in a given period of time.

Figure 5. Key Geographic Ideas (after, Victoria, 2004).

Geography and problem solving



In education generally, being able to solve problems is "among the most pressing of student needs" (Gregg, 1997, p. 250). Gregg describes a quantitative/qualitative study investigating the questions about maps that fifty (US) fifth and seventh grade students generated and answered. It sought to identify the process by which the participating map users obtained information from maps: map reading; map interpreting; or map inferring. Its findings demonstrated the transferable benefits of teaching problem-solving in schools, and argues for teaching problems that are not simple ones whose resolution will come through application of routine. Rather, they are complex, open-ended issues that require students to do three things: make sense of information; make connections among apparently disparate pieces of information; and, apply these understandings in unique ways.

Furthermore, and in life generally, people make geographical decisions every day (Salter, 1995). Since "physical and human processes … are inextricably tied to their geographical context" (Murphy *et al*., 2001, p. 41), all of life's decisions are made in a spatial context; either "in ignorance of it, or by understanding it" (Conolly, 2001, p. 46). Indeed, and perhaps in response to this, Marran (2003) cautions that decisions made without consideration of their geographical implications can be disastrous, and cites numerous examples where this has been the case.

Geography is well-placed to provide solutions because it investigates the geographic dimensions of society's problems (de Souza and Downs, 1994). And, although problem-solving is widely investigated in a range of disciplines (Gregg, 1997), geography is particularly well-suited to contribute to students' education in and about problem-solving. According to West (2004b), this is for two reasons. First, geography's spatial consideration of both physical and cultural elements affords it a holistic view of phenomena. Second, because geography is more analytical than descriptive, it addresses rather than discusses real-world issues. Dale (1995), among others, concurs. Casinader and Casinader (1994) explain this more simply, asserting that problem-solving skills are the core of geography. This is due to two interrelated factors: geography curricula are concerned with a multidisciplinary body of knowledge of global significance, as discussed previously; and, problem-solving involves choosing which pieces of seemingly unrelated information are relevant, to ensure that "sensible connections are strengthened and non-sensible ones are eliminated" (Gregg, 1997, p. 250). Thus, problem-solving in geography emphasises continued analysis of spatial and conceptual interconnectivity.

Silver (1994) further defines problem-solving as "both the generation of new problems and the reformation of given problems" (p. 19). In this regard, the spatial elements that constituted a problem are transformed rather than eliminated. Ward (2003) agrees with this point, suggesting that geography involves both problem-solving and creating products. These products are the practical solutions that are derived from studying an issue from a geographical perspective (Murphy *et al*., 2001). [These authors also offer a critical discussion of the products derived from investigation of the same issue from the perspective of other disciplines, including law, politics and sociology] For this, geography must emphasise "the relations that are developed when a person makes sensible, intentional decisions based on knowledge, skills and values from a geographical perspective in particular … situations" (Gerber, 1997, p. 42).

Evidently, geographical education offers the opportunity for students to gain skills requisite to problem solving. With specific regard to conflict arising from competing demands for natural resources, Queensland Senior Geography "seeks to explain compare, contrast, evaluate and make decisions about improvements for current and future use" (Queensland, 1999a, p. 15). One way that geography curricula can achieve this is by using visual forms of spatial phenomena to motivate students' geographic inquiries (McKeown-Ice, 1994).

Investigating spatial phenomena using an inquiry approach leads to more efficient and effective analyses, a direct consequence of which is the generation of a "more comprehensive and rigorous conclusion" (Casinader & Casinader, 1994, p. 42). Within Queensland, this approach involves four 'Key Questions', which are commensurate with the definitions of geography cited earlier (e.g., Fitzpatrick, 2001; Gritzner, 2002; Howitt, 2002):

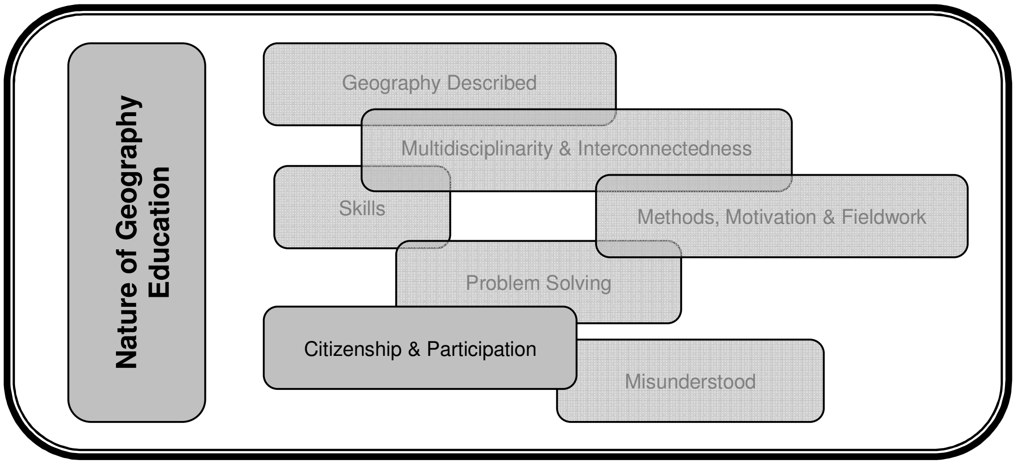
1. What and where are the issues or patterns being studied?
2. How and why are they there?
3. What are the impacts or consequences?
4. What is being and could be done?

Adopting an inquiry-based approach has educational benefits. Following his mixed methodology study of 480 (US) grade 7-12 students' responses to inquiry based learning, Klein (1995) concluded that inquiry-based learning experiences were more meaningful "because they studied current, relevant issues" (p. 364). However, since geographic inquiry is based on questions, its success demands that pertinent questions be successfully formulated and answered. However, for students to ask questions suited to geographic inquiry, they must first have been taught to ask geographical questions (Yates, 2000). Teaching problem-solving in a structured way enhances student capacity for geographic inquiry (Casinader & Casinader, 1994). While geographic inquiry proceeds toward the formulation of practical solutions, its value is not just in these products, but in the skills that are honed along the way (International Charter on Geographical Education, 1992). Reflecting the importance of this process, this Charter recommends that all tertiary courses should comprise a geographical element since geographical literacy is essential to quality decision-making (p. 13). Similarly, the [US] Partnership for 21st Century Skills includes "problem identification, formulation and solution" as one of nine elements constituting its ICT literacy map for Geography (National Council for Geographical Education, 2004).

Geography's practical approach to problem-solving enables the prediction of possible future scenarios (International Charter on Geographical Education, 1992, 2005). This is evident in the final question of the Geographical Route of Inquiry: What is being and *what could be done*? (Queensland, 1999a, p. 16, emphasis added). However, geography also teaches students to recognise that there is not always one right answer to a problem (Murphy *et al.*, 2001). Through a quantitative and qualitative study of student performance under teacher directed and inquiry approaches to learning, Klein (1995) identified that, in the latter, the lack of ideas for solving problems was a concern for students. To counter this, through the entire Route of Geographical Inquiry, students are encouraged to develop the skills of analysis and synthesis to incorporate an understanding of the issue being investigated with their own values (Healey *et al.*, 2000). The Syllabus itself states that "investigating issues about which there is no general consensus provides a very effective means by which students become aware of the values of different people … [and] understanding of how the values of different groups and individuals shape their world" (p. 6). Thus when problem-solving in geography, decisions are "nearly always compromises" (p. 3).

For these reasons, geography claims to be good at solving complex problems associated with social and environmental matters, using a wide range of common forms of communication, and exercising values in situations involving human-environment interactions (Howitt, 2002; International Charter on Geographical Education, 1992). To achieve this, Queensland's Senior Geography emphasises a thematic issues-based approach moreso than a systematic approach (Gerber, 2001). Hence, by teaching students to analyse current and predict future situations within a context of investigating real-world issues, school geography empowers students to "develop more comprehensive responses to the questions which are posed for them in their future lives" (Casinader and Casinader, 1994, p. 42). Or, as Howitt (2002) says, "geography … shapes how people imagine themselves" (p. 7).

Geography's role in the world; citizenship and participation



One of the seven Global Aims of the Queensland Senior Geography Syllabus is to "develop the knowledge, abilities and ethical commitment to participate as active citizens in the shaping of the future" (Queensland, 1999a, p. 6). The concurrence of two factors gives credence to this need: the increased emphasis on citizenship globally, and the increased ignorance of matters affecting the globe and its citizens (Gritzner, 2003). Geography serves to address these by making many valuable contributions to our understanding of the world (Young, 1995). Specifically, the US Geography Education Standards Project views geography's contribution as being to

> discover and capture [Earth's] horizons in order to understand how people live and work to utilise resources. This understanding is more urgently required than ever for all students because of new global realities – the interconnected, integrated and interdependent character of our lives" (de Souza and Downs, 1994, p. 33).

If we accept Conolly's (2000) assertion that educators have the responsibility to ensure that young people "are adequately provided with the knowledge and skills which allow them to understand themselves in their society and environment" then it becomes essential for those educators to understand the nature of the issues confronting societies and environments (p. 160). According to Howitt (2002), all global issues confronting contemporary society have a geographical basis. To support his view, Howitt discusses nine examples, ranging from regional inequality to issues affecting the tourism industry. Gritzner (2003) further observes geography's influence in four realms of our daily experience: environmental (e.g., resources and climate); political (e.g., planning and zonation); economic (e.g., property values, commodities); and, social (eg demographic composition).

Investigating such a range of issues geographically equips students to better understand and interact in their worlds. To elaborate, Walford (1987) states the "understanding of the dimension of space and its implications for individuals, groups, and whole nations, is essential to a proper appreciation of many of the major issues which confront the modern world" (p. 60). Further, "much of geography's power lies in the insights it sheds on the nature and meaning of the evolving spatial arrangements and landscapes that make up the world in which we live" (Murphy *et al*., 2001, p. 42). Similar claims are made by, among others, Howitt (2002).

This investigation of the spatial dimension of observed phenomena is one of the reasons why Geography is viewed by many as the ideal place for comprehensive global education within a school's curriculum (e.g., Murphy *et al*., 2001; Rawling, 2000). Another significant factor is that geography education attempts to engage students critically with their world (Howitt, 2002), in response to "concurrent globalising and localising tendencies" (Rawling, 2000, p. 210). By recognising local differences, but within global processes, geography education teaches students to respect diversity and multiple perspectives (Murphy *et al*., 2001). Through this understanding comes added legitimacy of the solutions it offers. In this way, geography in school serves the role of developing students who are "responsible citizens and effective leaders in the world that they will inhabit as adults" (Marran, 2003, p. 43).

However, changes in society have led to changes in what geography involves (Murphy *et al*., 2001). The implication is that geography education cannot remain static. Rather, attempting to make sense of the world geographically "must be premised on some understanding of changing human and physical patterns" (Murphy *et al*., 2001, p. 41). Four years earlier, Cox (1997) asserted that the need for meaningful learning experiences could not be exaggerated. By meaningful, he referred to experiences that help students to understand the world that they live in. Or, quite simply, to understand what is where, why there and why care (Gritzner, 2002).

By linking student learning with actual global issues, geographical education can in this way become expressed in one's private life (Gerber, 1997). Perhaps more significantly, and beyond the importance of earlier arguments for a geographical education, Spencer (2005, p. 305) observes that,

> in 'doing geography' with the child, one is participating in a process which is even more fundamental and therefore more important still: namely, one is in a humble way facilitating the child's very personal development of self-identity which will shape much of their lives, their values, sense of belonging and self worth.

In this manner, understanding of the KGIs arising through the Geographical Route of Inquiry, when applied to current and topical issues, engenders the geographical thinking that is fundamental for citizenship (Fernald, 1996). Thus, geographical education promotes life-long learning and geographical literacy (Chiodo, 1997; Downs, 1994; Gerber, 2001; Miller, Keller & Yore, 2005). An adjunct to this only serves to strengthen the argument for a geographical education, where a lack of geographical literacy "imposes a significant burden on the nation, its communities, environments and neighbours" (Howitt, 2002, p. 7).

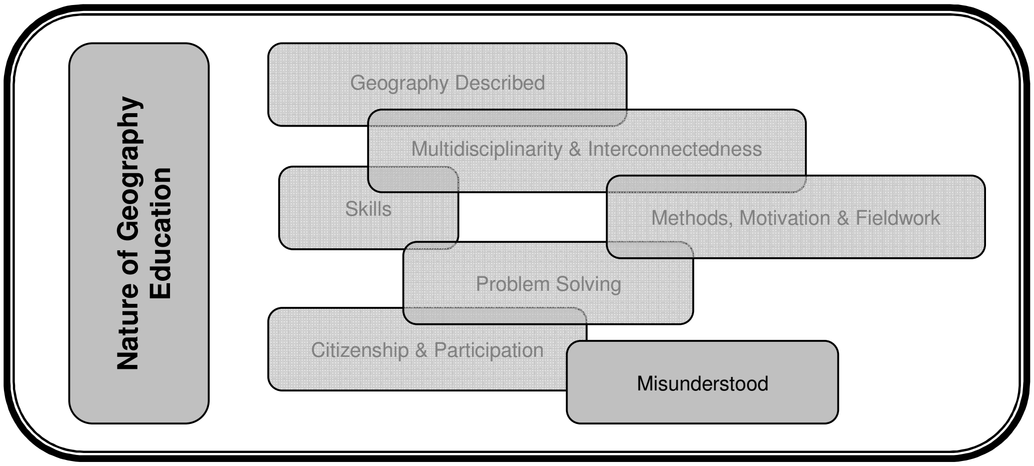
One particular strength of geography education is its capacity to enhance environmental education. Gerber (2001) undertook a global survey of geographical educators from 32 nations in 2000. He investigated, among other things, the perceived role of geographical education in preparing students for active citizenship and as a vehicle for sustainability. Interestingly, this study found 'strong support' for the inclusion of environmental education in geography education; the inclusion of citizenship education received only 'moderate support' (Gerber, 2001).

Conolly (2000) agrees that geography plays a "considerable role" in furthering sustainable management of resources (p. 163). This is because all issues dealt with by governments can in some way be informed by geographical thinking. Again it seems that the quality of decision making made by governments may be influenced by the quality of thinking undertaken by geographers, an idea more recently supported by Kidman and Palmer (2006). Within contemporary information economies, this means that "the development as a learner is as important as mastering knowledge" (van der Schee, Leat & Vankan, 2006, p.124). When considering this, Conolly (2000) notes that geography education "might enhance commercial profitability and such areas as environmental understanding, effective decision-making in spatial contexts and cultural and resource understanding of overseas markets" (p. 162-163). However, with reference to the broader influence of geographical study, Slater (1995, p. 5) concludes that

> although geographical studies can contribute to student employability and usefulness in the economic side of societies, … it has a wider potential in the life of thinking, critical, independent citizens and human beings who have lives to live and develop beyond the economic.

Or, more simply put, geography is "learning for living" (Gritzner, 2003, p. 91).

Geography: a misunderstood subject



"…no-one really knows what we do" (Year 12 Geography student, in West, 2003a, p. 29).

"Geography has lost its curriculum identity … [which] is the biggest threat to the continuing contribution of geography in Australian schools" (Rawling, 1997, p. 6). Over a decade earlier, Chiplen (1984, as cited in Bliss, 2006) observed that "[g]eography appears to be particularly misunderstood and to be singularly unfortunate in not being able to shed the really obsolete, naïve images of itself" (p. 158). Bliss reminds us that, over two decades later, "little has changed" (p. 152). Dale (1995) believes that the very name, 'geography', is misleading, since it no longer truly reflects what is done by geographers. In simpler terms, geography is misunderstood (Greiner, Wikle & Spencer, 2002).

Such misunderstanding of geography may be compounded by limited public awareness of it (Conolly, 2001a). Moreover, misconceptions about geography are "based probably on studies of geography in the distant past of the lives of the people making these claims" (Gerber, 1997, p. 44). More recently, Nick Hutchinson, Chair of the Australian Geography Teachers Association listed fourteen reasons for the demise of geography in post-compulsory education in Australia (Hutchinson, 2006), including the slow response of geography educators in updating their image and to taking initiatives to move community thinking about the subject away from the "capes and bays" mentality of past perceptions (p. 195). A specific example of an area where knowledge of geography is lacking is in the business sector, where few advertised positions require potential employees to have studied geography (Conolly, 2000).

This misunderstanding about the nature of geography inhibits its future development (Rawling, 2000). However, this matter is further complicated by difficulties in defining geography creating added difficulties in communicating its value (Gritzner, 2002). In the face of these challenges, "community awareness of geography is vital for national interest, since all contemporary issues have a geographical aspect" (Conolly, 2000, p. 164). The implication of misconceptions of the role of geography leads to geographical problems not being solved by geographers; inappropriate solutions, which may serve to exacerbate rather than ameliorate issues (Murphy *et al*., 2001). These authors suggest that the poor understanding of what geography is (and isn't) is both a cause and effect of the subject not carrying "enough intellectual or social clout" (p. 43).

One factor which contributes to this misunderstanding is the perception that geography can be defined by its content (Fernald, 2002). Dale (1995) adds that geography is commonly perceived as an "encyclopaedic discipline" (p. 14). While Gerber (2001) found that most people see geography as 'at least important', both Fernald (1996) and Hutchinson (2006) assert that the public image of geography is misinformed. The reasoning for the perception of geography as being 'at least important' could, therefore, be based on an incorrect understanding of what the subject is. Paradoxically, while the potential contribution of geography is substantial, this contribution is poorly understood by people, including those who influence student subject choice specifically, and curriculum decisions generally (Conolly, 2001a, 2001b; Crabb, 1995).

From the 1960s to 1980s, geography was "regarded as a marginal discipline" (Murphy *et al*., 2001, p. 41). In more recent terms, Baldwin (2002) cites three reasons for the decline in the uptake of Senior Geography in New Zealand across the decade to, 2001. First, competition from other subjects. Second, concerns about the relative difficulty in getting high marks, when compared with other subjects. Third, pressure related to limited time to cover essential material. To this, Stoltman (1997) adds that competition within school timetables compounds this, while Hutchinson (2006) adds that the perception that other social sciences contribute more to future employment than did geography does likewise.

Within the context specifically addressed in this thesis, synergetic focus groups of students studying Senior Geography at one Queensland school confirmed these suggestions (West, 2003a, 2006c). Notably, some students expressed frustration with the common misconceptions held by others and believed that other, perhaps more clearly defined subjects, out-competed geography because of these. While they did not emerge as distinct categories of description within that study, my personal experience is that students in Queensland are often concerned about what they believe is the disproportionate amount of time required to complete Geography related tasks, and the difficulty of getting high marks when compared with other subjects.

Following this concern, a two-tailed Wilcoxon signed-ranks test was used to evaluate whether Geography results were, indeed, significantly different from other results in Queensland's senior curriculum. This investigation revealed that, between 1998 and 2003, significantly lower results were awarded for Geography than in some other Subject Classes. Distribution of levels of achievement also suggest that high results are less common in Geography than most other subjects.

It is almost a truism that the subjects offered by schools are influenced by external factors (Alexander, 2006; Slater, 1995). Curriculum thus reflects the things that are considered socially, economically and educationally desirable (Casinader & Casinader, 1994). Hence, "winning a place" in the curriculum often requires the utilitarian and/or vocational benefits to be stressed more than the contribution of the subject to a broad education (Rawling, 1997, p. 6). Competition within the curriculum is discussed by a number of other authors, many of whom also identified shifts toward vocational pressures as the major competitive disadvantage of geography (Bliss, 2006; Gerber, 1995a, 2001; Rawling, 2000; Smerdon, 2006). Within this climate, structural and governmental changes influence what is taught in school geography, but these are not necessarily based on a true understanding of what the subject offers, by way of contributions to vocational and general education (Berry, 1996; Hutchinson, 2006). Indeed, it is ironic that while much of school administration is motivated by increasing demand for vocational emphases, this threatens subjects such as geography that offer tremendous contributions to the world of work (Slater, 1995). This is where consideration is needed for ways of publicising the role of geography and its contributions, especially in business (Conolly, 2000).

However, while most authors view competition as a threat to the future of the subject (e.g., Bliss, 2006; Hutchinson, 2006; Slater, 1995), Young (1995) believes that threats from other disciplines and multidisciplinary offerings should not be a concern, but rather should be an impetus to "make the best use of our skills" (p. 8). However, the reality is that, in universities, Gerber (2001) found "many degree programs do not see the relevance of studying geography in their curricula" (p. 353), citing law, medicine and engineering as areas that have a readily identifiable spatial element.

Furthermore, it is perhaps not surprising that the number of students studying geography has declined, with the number of schools offering geography also declining (Berry, 1996). In New South Wales, less than 20% of students studied Geography at a post-compulsory level in 1998**,** while about 50% studied it in the compulsory years of secondary school (Conolly, 2000). Student enrolment in Senior Geography in Queensland has also declined steadily. Table 4 illustrates this, where the proportion of Grade 12 students studying geography has declined from 18.5% in 1993 to 10.7% in 2006. Perhaps interestingly, the proportion of students studying Senior Geography who are OP-ineligible has increased from 20.6% to 33.7% during the same period.

Table 4

Queensland Year 12 student enrolment data, 1993-2003 (Source: Queensland, 1999b; 2004a; 2004b; 2004c; 2006a; 2006b; 2007a; 2007b).

		OP eligible		**OP ineligible**		**Studied Senior Geography**	
Year	**No. students**	**Total**	**%**	**Total**	**%**	**Total**	**%**
1993	34436	27336	79.4	7100	20.6	6532	18.9
1994	33391	25985	77.8	7406	22.2	6255	18.7
1995	32224	25118	77.9	7106	22.1	5756	17.9
1996	32763	24893	76.0	7870	24.0	5648	17.2
1997	33822	25958	76.7	7864	23.3	5512	16.3
1998	35394	26736	75.5	8658	24.5	5741	16.2
1999	37032	27750	74.9	9282	25.1	5750	15.5
2000	38729	28293	73.1	10436	26.9	5526	14.2
2001	38441	27812	72.3	10629	27.7	5312	13.8
2002	39314	28172	71.6	11142	28.4	5157	13.1
2003	39359	28545	72.5	10814	27.5	5170	13.1
2004	38471	27235	70.7	11236	29.3	4590	11.9
2005	38953	27025	69.4	11928	30.6	4325	11.1
2006	39579	26230	66.3	13349	33.7	4241	10.7

In the face of such a steady decline, it is perhaps worth considering impediments to the subject. While much has been written on this topic (see, for example, Bliss, 2006; Hutchinson, 2006; Smerdon, 2006), Conolly (2000) succinctly cites five constraints confronting geography education: institutional; political; academic; business; and media. He highlights that local government has no legislative role in education, despite this scale providing many opportunities for geographical investigations; an opportunity that is clearly implied in the Queensland Senior Geography syllabus, with its prescription of both field studies *and* studies of phenomena at local scales. Rather, national interests are influencing state education policy through funding, which emphasises, among others, integrated curriculum which presents no overt emphasis on geography, such as Civics Education and Studies of Society and Environment. Similar concerns are addressed by, among others, Freeman (2006), Hutchinson (2006), Kriewaldt (2006) and Smerdon (2006). The growth in student enrolment in OP-ineligible courses of study, from Table 4, reflects recent emphases upon vocational education and training. Both of these trends add further credence to the suggestion that, quite simply, some students never study geography (Conolly, 2000); and to Ballantyne's (1996, p. 180) question, "how can geography educators influence students if they are not exposed to the subject?"

If geography is going to keep its place in the secondary curriculum, it has to be taken seriously by society (Gerber, 2001). Of course, an adjunct to this is that the subject needs to be in the curriculum in order to demonstrate its value. Ballantyne (1996) investigated the reasons why Queensland Year 11 students did or did not include Senior Geography in their subject mix. Following statistical analyses of the questionnaire responses of 169 students who did select Geography and 174 who did not, he concluded that two ways to affirm the subject's future "would be to highlight its perceived general interest value and to promote its relevance to the world of work" (p. 179). He also recommends that "institutional factors which influence students' exposure to and familiarity with the subject" be addressed (p. 179). Similarly, in response to the increasingly competitive environment, Healey *et al.* (2000) assert that geography's transferable skills should be emphasised. More specifically, Baldwin (2002) provides five mechanisms by which the profile of geography can be raised:

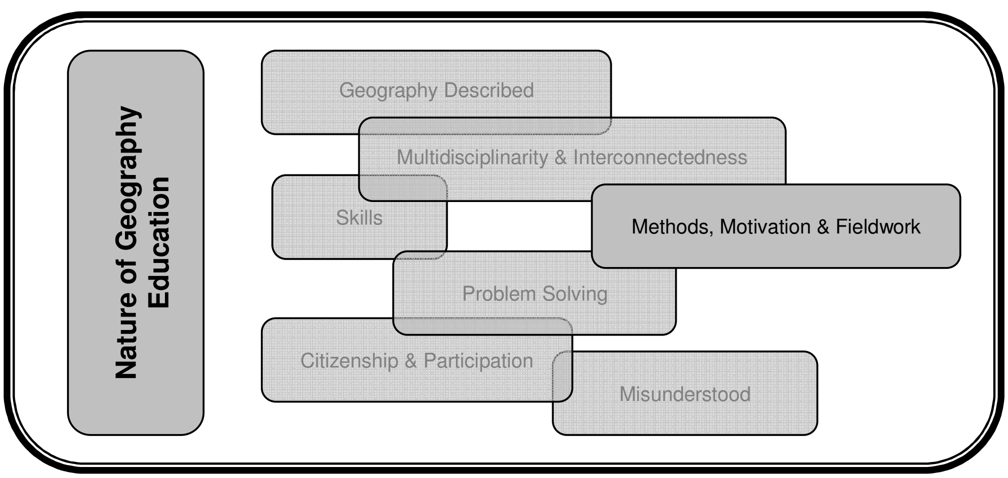
1. Interesting teaching strategies (e.g., cooperative learning, various resources, catering for different learning needs);

2. Use of ICTs;
3. Celebrate and publicise;
4. Events to promote subject; and,
5. Link subject relevance to contemporary issues (e.g., investigate current local issues).

In this respect, Slater (1995) believes that the future of geography will be determined by student perceptions of the subject's value in terms of knowledge *and* skills ability. To address this, the discipline needs to be visibly credible (Crabb, 1995; McInerney, 2006; Smerdon, 2006).

Discussion thus far has focused on the benefits of a geography education, rather than the influence of selected teaching approaches in determining the extent to which those benefits can be attained. Since the way information is taught influences how the information becomes available (Gregg *et al.,* 1997), consideration of teaching methods and learning experiences will also influence the extent to which the potential benefits of a geographical education, as discussed, are realised within classrooms.

Teaching Geography: Methods, motivation and fieldwork



It is obvious from discussion thus far that a geographical education offers many benefits. However, as with all subjects, "motivating and challenging pupils is a real concern of many teachers" (van der Schee *et al.*, 2006, p. 132). Perhaps in recognition of this, geography education is shifting from a teaching to a learning focus (Gerber, 2001). This is because sound geography teaching experiences must be offered so that students can adequately respond to "present and future challenges" (Stoltman, 1997, p. 37). Indeed, "[geography] continues to lead in the creation and implementation of pedagogic innovation" (QAA, 1999, as cited in Healey *et al.*, 2000, p. 4). [The impact of recent reforms of geography education on teaching method and resources are outlined by Reinfried (2001) and Hutchinson (2006), among others.] Teaching and learning experiences in geography are as broad as its content and skills, e.g., laboratories, practical tasks and reports associated with the physical sciences, and seminars and essays associated with the social sciences and humanities (Healey *et al.*, 2000). The present discussion will focus on several aspects of the teaching-learning process: ICT, relevance, thinking skills and fieldwork.

In simple terms, Gerber (1995a) noted a decade ago that we can expect that, if students are exposed to richer experiences elsewhere, they will not choose the geography classroom. He further noted that geography's emphasis on multimedia also provides opportunities for it to outcompete other school subjects; it has a "comparative advantage as a field of study where visuals provide the raw material for learning" (p. 55). Although they were made a decade ago, Gerber's observations remain valid, especially with respect to the tools used in geography classrooms changing to reflect an increased emphasis on technology (p. 52). These observations were more recently confirmed by Healey *et al.* (2000), who noted that the influence of such changes toward resource based learning and ICTs have driven many pedagogical changes in geographical education.

Indeed, there is little doubt that increased technological capacity has increased both what we know and the rate at which we acquire more knowledge about the earth (Gritzner, 2003). Therefore, it appears that truth still surrounds Gerber's (1995a) decade old claim that "success in geography must involve a response to technology that will enable all of us to make maximal use of technology in our lives" (p. 50). Dale (1995) believed this use of technology would empower us to resolve spatial issues in more sophisticated ways. From an educational point of view, it was expected then (as now) that the learner would exert greater control over the learning process as technology increases (Chalmers, 2006; Gerber, 1995a). This suggestion became apparent over 15 years ago, when Gerber (1992a) employed a survey methodology with 193 geography educators from fourteen nations to determine their perception of, among others, the benefits associated with the use of technology: more teaching strategies; increased student interest in the lesson; less preparation and delivery time; improved visualisation by students of difficult concepts; up to date data; more and better individualised learning; and easier data management. However, even a cursory review of literature since then reveals that these claims remain highly contested (see, for example, Godfrey, 2001; Montgomery, 2000; Roschelle *et al.*, 2000; Turner and Beeson, 2003).

The importance of ICT for geography to establish and maintaining a profile in Queensland is discussed by Smerdon (2006). More generally, its role in geographical education is discussed at length by Gerber (1995a). In brief, it is founded on three interrelated factors. First, ICT are an integral element of student lives. Second, and as discussed earlier, ICT have a strong graphical component. Finally, learning activities require relevance for intended learners. By corollary, it is logical then to presume that "the geography classroom, if it is to respond to learners' needs, will have a strong graphic and technological element" (p. 55). However, Miller, Keller and Yore (2005) offer a word of caution following their on-line survey of 80 predominantly North-American 'expert' geography educators to identify desirable elements of a curriculum that is expanded to facilitate digital information literacy. They concluded that: given existing concerns about the place of geography in the K-12 curricula, it

> may be a luxury, therefore, to worry about strengthening digital geographic information literacy when the curricula already struggle to find sufficient emphasis for basic geographic literacy and for fundamental concepts and abilities of geographic information handling (p. 256).

Further discussion is provided by Bednarz and Audet (1999), Keiper (1998), Lloyd (2001), Lo, Affolter and Reeve (2002), and, Mara Chen (1997).

Meaningful learning can be encouraged through activities that involve reflective thinking, including "consistent application of the skills associated with logical and critical thinking", and analysis of values in context (Cox, 1997, p. 50). The potential for increasing student motivation comes from recognising the relevance of geography's content to the real-world, and not just in a vocational context (Rawling, 1997). To this, Ballantyne (1996) recommended that the content selected for geography lessons be "both relevant and current" and "demonstrate the practical relevance of the subject to everyday living and problem solving; make explicit the connections and the world of work; and enable a decrease in the amount of writing undertaken in class" (p. 180). Real-world issues, especially local studies, encourage student empowerment (Klein 1995). Increasing student empowerment requires that students be involved in inquiring into and addressing local problems (Klein 1995). This can be encouraged through the involvement of parents, local industry, media and community organisations, making geography a more attractive choice for students and validating the work being done (Conolly and van Norden, 2001). Such relevencies make learning in geography an active process.

This importance of active learning in geography education was noted in Sack and Petersen's (1998) investigation of an opportunistic sample of 1400 grade 4, 5 and 6 students in a US district that emphasised geography in its curriculum. Student attitudes were surveyed, with the only statistically significant difference between the class that rated geography highly and the one that rated geography poorly being active teaching methods. They concluded that by actively involving students in geography lessons, their attitudes might improve (p. 130). Rawling (1997) agreed, citing the involvement of fieldwork, school-industry links, use of social, economic and environmental issues as starting points for inquiry, active learning processes and critical reflection as means of improving the quality of geography teaching.

In a related vein West (2003a, 2006) investigated conceptions held by Queensland Senior Geography students of the role of geography in their futures. Emerging from analyses of the synergetic focus group discussions were five categories of description. Of significance for the present discussion were four of these categories: geography as a misunderstood subject; geography as an enabling subject; geography as a form of general knowledge; and, geography as a means of interacting with the world. This investigation revealed a generally positive view held by students toward geography, arising from their perception that studying the subject presented some immediate and future value for them and the societies in which they participate. Although it predates the current Senior Geography syllabus, Ballantyne's (1996) investigation discovered a similar result, with 75% of geography students indicating that they would recommend the subject to a friend for reasons of either interest or practicality.

For many students, one of geography's more interesting aspects is fieldwork (Ballantyne, 1996; Conolly and van Norden, 2001). According to Bliss (2006), fieldwork is "an essential part of the study of Geography. It is a geographical tool that facilitates the understanding of geographical processes and geographical inquiry" (p. 157). Many authors agree, e.g., Kriewaldt (2006) and Smerdon (2006). Most geography fieldwork involves projects: collecting information by observing, collecting and measuring (Healey *et al.*, 2000). Therefore, when it includes fieldwork, geography in schools readily encompasses multiple intelligences, allowing "students to develop skills in a variety of intelligences not always utilised in a classroom context" (Ward, 2003, p. 33). Fieldwork also allows students to develop important skills in group work and individual initiative (Healey *et al.*, 2000), and to experience first hand the transferability of what they learn in class (Ballantyne, 1996).

This latter idea was more recently explored within a British primary school context. Halocha (2005) collected and analysed the work of 150 eleven year olds following their participation in fieldwork. Students were asked to represent what they had thought they learnt during the field visit. Initial results of this investigation revealed students made clear connections between concepts introduced in class and those experienced during field studies.

Atkin (2003) further suggests that immersion in fieldwork is an effective way to arrest student apathy in geography because it stimulates their curiosity, such as when investigating local issues. By involving them in fieldwork and practical tasks at local levels, students' interest in and understanding of global issues are promoted (Klein, 1995). Specifically, he says, "local inquiries can help students to link global issues to their own lives and build their democratic citizenship skills" (p. 366).

In terms of skills development, Hermann (1996) provides a lengthy summary of the benefits of fieldwork to graphicacy, and specifically to map-reading skills. Undertaking fieldwork in the students' local areas enables them to "understand maps from an experiential perspective" (p.163). Student conceptualisation of thematic maps is better when they have experienced maps of the local landscape while functioning within that landscape. Further, fieldwork using maps allows students to transfer their experience to other maps, such as those at larger scales; student knowledge and understanding are deepened. The use of maps in fieldwork is supported by numerous others (e.g., National Research Council, 2006), including Gerber (1995a), who asserted that graphic and technology literacies should be integral to geography education, not discrete components of it.

However, time and other limitations affect the amount and quality of fieldwork that is undertaken (Berry, 1996; Smerdon, 2006). Engaging students in local inquiry does also require the support of others, including school administration, parents and community (Bliss, 2006; Halocha, 2005; Klein 1995). Also, from my own experience, organising such experiences such that they provide benefits in line with syllabus requirements and are enjoyable for students requires an understanding of the inquiry process as it can be applied to the issue being studied. This is an experience shared by several contributors to the recent Forum about "Geography and Geographical Education in Australia", published by *International Research in Geographical and Environmental Education* (e.g., Kriewaldt, 2006; Smerdon, 2006).

Notwithstanding the apparently positive perception of students to studying geography and undertaking fieldwork, Crabb (1995) argues that the "pleasure and excitement that comes from engaging in geography has to be introduced in school" (p. 9). However, in Sack and Petersen's (1998) attitudinal study, described above, the positive attitude of geography teachers to their subject was not reflected in the attitudes of their students. Since the teacher's approach to the classroom influences the quality and quantity of meaningful learning that occurs (Cox, 1997), this could be due, at least in part, to Murphy *et al.*'s (2001) observation that few Australian secondary teachers of geography possess sufficient training and/or enthusiasm to impart enthusiasm into their students. This is a claim echoed by Fernald (2002) and Robertson (2004), both of whom note that many teachers have had little or no training specific to geography and/or geography teaching, and that they are therefore unaware of its specific methodology. [Such a statement is not surprising given the declining number of tertiary institutions that offer Geography methodology within their educational faculties (Bliss, 2006).] It is important, then, that geography teacher training must develop competence in teaching geography as well as geography skills and enthusiasm (Ballantyne, 1996; Hutchinson, 2006; Rawling, 1997). Similarly, Sack and Petersen (1998) and Kidman and Palmer (2006) call for existing and potential geography teachers to receive training that better equips them to teach actively.

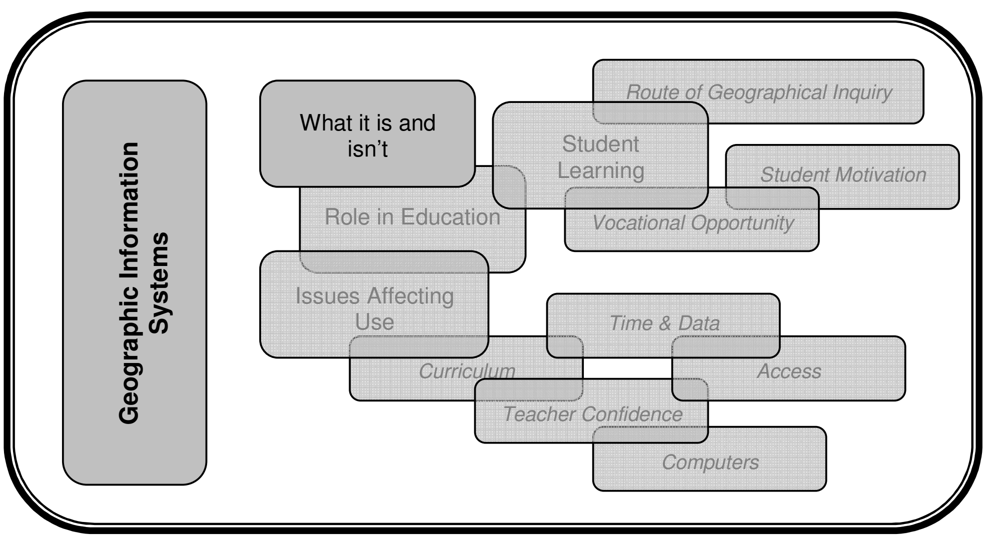
However, the nature of that training must be based on an understanding of the influence of different approaches to geographical education on students. Calls for empirical research into this have been made for a long time. In 1996, Fernald (p. 3) claimed that research into the methodology of geography and geography education will assist teachers to develop more meaningful learning experiences. This reflects the many calls made before and since (e.g., Baker and Bednarz, 2003). Similarly, in response to increasing opportunities presented through technological advancement, calls are being made for investigation into the potential influence of newer technologies on geographical education. And it is to this that this discussion will now turn.

Geographic Information Systems

One tool that has experienced transformation arising from advancement in computer technologies is geographical information systems (Baker and White, 2003; Wilder, Brinkerhoff & Higgins, 2003). In parallel with this has been the growing interest of educators in the potential of GIS within schools. Indeed, Wiegand (2001) has been so bold as to claim that GIS represent the "single biggest contribution geographers have made to society and economy since the Age of Discovery" (p. 68).

However, understanding its likely educational impacts first requires that GIS be defined. This section will define GIS in terms of what it is and what it is not, and provide an historic overview of its role in education. Its potential contribution to student learning will then be evaluated through discussion of how its use influences inquiry based learning, student motivation and vocational opportunity. Five issues that affect the uptake of GIS in schools will also be reviewed: curriculum; teacher confidence; time and data; computers; and, access. Finally, this chapter will conclude with an outline of questions arising from the literature and specific directions of the present study.

GIS: What it is and isn't



GIS unite spatial data that can somehow be referenced by geographic coordinates. They are "a collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update and electronically manipulate, analyse and display all forms of geographically referenced information" (ESRI, 1991, pp. 1-2). More recently, Pun-Cheng and Kwan (2001) similarly defined GIS as "a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modelling and display of spatially-referenced data for solving complex planning and management problems" (p. 88). Comparable definitions are offered by Gerber (1995a), Schuurman (2004) and West (2003b).

In recent years, however, GIS has become more synonymous with just the computer software able to store and use data describing places and patterns on the earth's surface. Hence, for the current investigation, GIS is considered to be the software, and its associated digital data. Although possessing various degrees of sophistication and application, all GIS perform essentially the same function: encoding, management and manipulating spatially referenced data (Curran, 1985; West, 1998a). Reflecting what it sees as the inadequacy of many definitions in omitting to "capture the essence of the technology and its social implications", the [US] National Research Council (2006, pp. 158-9) defines GIS as "integrated software systems for the handling of geospatial information; for its acquisition, editing, storage, transformation, analysis, visualisation, and indeed, virtually any task that one might want to perform with this information type".

It is important to clarify that GIS is not multimedia computer software; it is but a single component of a multimedia environment. However, it is similar to that of multimedia, where "the unique capability of …linking together many disparate pieces of information on a single screen can dramatically simplify the information-gathering process, giving the student more time to analyse and think about the information" (Kam, 1996, p. 206). In this regard, GIS are tools that access data from a variety of sources and in a variety of formats, and which can be displayed in an equally large array of formats (Gerber, 1995a; Pun-Cheng and Kwan, 2001).

The way GIS store data is fundamental to an understanding of its educational potential. GIS store sets of related data in layers that are referenced to geographic coordinates, e.g., latitude and longitude. This synchronicity allows different data types to be integrated, such as census, satellite, demographic and economic information (Langley, 2001). Langley also suggests that GIS' simultaneous mapping of multiple layers facilitates a greater understanding of the relationships by enabling rapid complex spatial analyses of datasets to be made (p. 93).

Beyond enabling "more accurate and meaningful analyses of geographical phenomena" (Pun-Cheng and Kwan, 2001, p. 90), such overlay maps also enable the results of complex analyses to be rapidly summarised and presented to various, "non-expert audiences" (Langley, 2001, p. 95). Langley continues to emphasise that the visual summaries of GIS "mean much more to us than tables of numbers, for example" (p. 97). In this respect, GIS' capacity to unite spatial features with more descriptive information engenders its seemingly greater utilitarian value, when compared with traditional paper maps (Pun-Cheng and Kwan, 2001).

Table 5

Comparison of the system requirements of ArcView GIS (with common Windows NT 4.0, or higher, platform) (ESRI, 2007).

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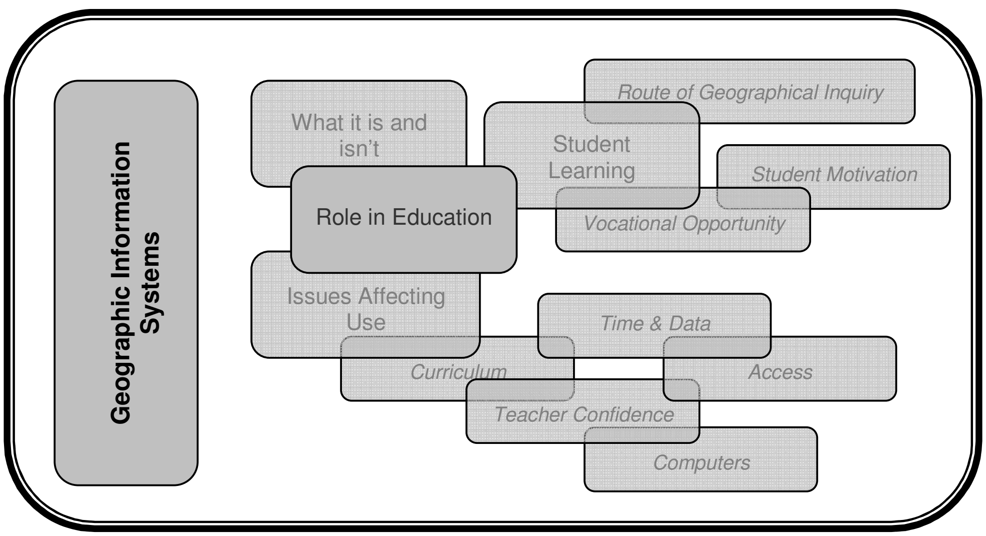
Please consult the hardcopy thesis
available from the QUT Library

But this is not new. Kerski (2001) notes that "for over 30 years, GIS has been capable of analysing complex phenomena from local-to-global scales, both spatially and temporally, in an interdisciplinary environment" (p. 82). While this may be true, it has been the development of more efficient microprocessor technology and affordable software that have enabled GIS to more efficiently manage and utilise spatial data (Hoel, 2004; West, 2004a). Indicative evidence of this is the doubling of *ArcView*'s memory requirements and almost doubling of processor speed requirements between 2001 and 2007 (Table 5). Because of this growth in data-handling capacity and affordability, environmental and social practitioners can interrogate, analyse and manipulate great volumes of data, make decisions about the world that they represent and communicate this information clearly and concisely (Smith and Hania, 2000).

GIS in Education



It appears that teachers believe that GIS present many uses in education (Brodie, 2006; Kidman & Palmer, 2006; Langley, 2001). This view is substantiated by Kerski's (2001) US survey of 1528 US teachers who owned one of three common desktop GIS applications; *Idrisi*, *MapInfo* or *ArcView*. His survey yielded a 28% response rate, from which he drew statistical conclusions about the geographical and curricular extent of GIS' implementation in US secondary schools, and how that implementation was occurring. His study revealed that

88% believed that GIS made a "significant contribution to learning" (p. 79). Also found from this study was that teachers' own "descriptions of lessons in which they use GIS illustrate the appeal, versatility and applicability of GIS in education" (p. 78).

In 1999, more than 500 000 *ArcView* users existed globally. Of these, fewer than 1500 were educators (ESRI, 1999, as cited in Kerski, 2001). Of the 422 teachers who responded to Kerski's study, only 5 of them had used it 10 or more years beforehand. By contrast, the number of users had increased by 155% to 138 in the two years preceding the survey (Kerski , 2001). This increase in the number of schools which own GIS is, in large part, due to increased technological capacity to handle spatial data (Pun-Cheng and Kwan, 2001). Of course, as with Kerski's findings, possessing GIS is not a certain indicator of its use.

Within schools, Fitzpatrick (2001) offers a valuable summary of GIS' recent role. He notes that GIS has been used in many ways, which are largely influenced by local, state and federal curriculum requirements, including:

- printing maps;
- collection and collation of local data;
- as an enrichment tool for some students;
- cooperative and collaborative learning in small groups; and,
- in whole class tasks using computer laboratories for real-world tasks.

This summary reflects the descriptions of GIS use made by many other authors (see, for example, Dascombe, 2006; Kidman & Palmer, 2006; McInerney & Shepherd, 2006; Turner and Beeson, 2003; West, 1998a, 2006; Wiegand, 2003; Wilder *et al.*, 2003). It also mirrors the range of applications in Australian schools, a sample of which is shown in Table 6. According to Langley (2001), such a variety of GIS' applications reflects the extent of geographical information present within the educational environment.

Table 6

Sample GIS activities undertaken in Australian secondary schools.

School (State)	Project Description	Source
Blackheath & Thornburgh College (Qld)	Formulation of Burdekin Rangelands Strategic Plan	West (2004a)
Caroline Chisholm High School (ACT)	Assessment of the potential impact of geohazards, such as earthquakes, at their school	Kids Map Hazards in Space for a Day (2003)
Coffs Harbour High School (NSW)	Development of a rejuvenation plan for a nearby sand dune habitat	Personal Communication
Findon High School (SA)	Development of local area disaster plan	McInerney (2003)
Latrobe High School (Tas.)	Deciding the best location for parent-teacher night interviews	Tasmania (2003)
Presbyterian Ladies College (Vic.)	Analysis of national membership and fundraising outcomes for Amnesty International and Cancer Council	Beeson (2006)
Pimlico State High School (Qld)	Investigating the impact of graffiti in the local area	Jenner (2006)

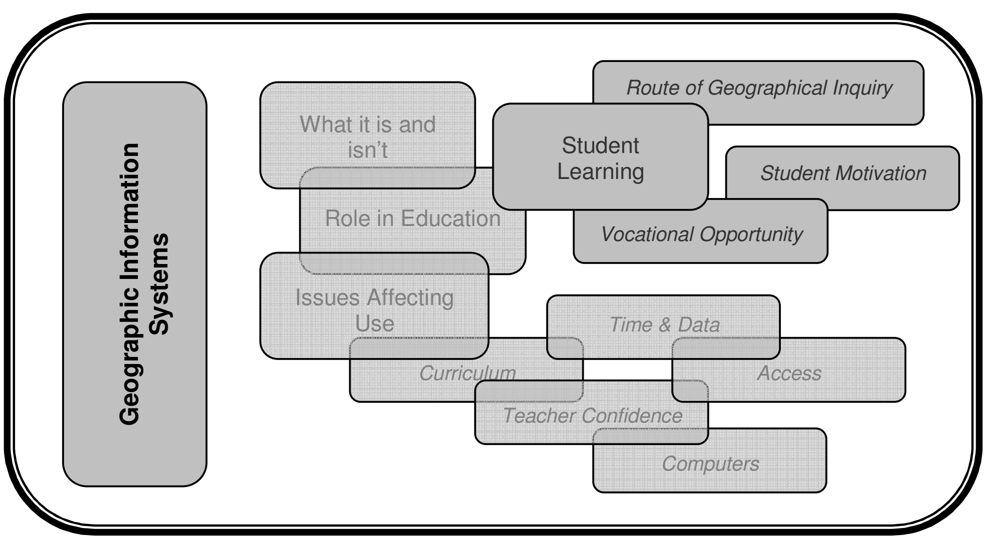
However, while this variety of data creates an equally wide array of applications, this seemingly unlimited potential of GIS' applications may create limitations to its use. Pun-Cheng and Kwan (2001) argue that, in spite of its increased accessibility, GIS' use in schools has been met with "hesitation" (p. 90). Kerski (2001) offers a possible explanation, arguing that "multiple pathways, methods, and curricula exist, rather than a single entry point" (p. 81). This may explain his further observation that GIS in education has not yet been "institutionalised," with few teachers programming much more than a few lessons, let alone an entire curriculum (p. 81). Interestingly, some apprehension regarding GIS' use within geography in Australia's Northern Territory is derived from the belief that it "will be difficult to restrict GIS exclusively to geography due to its wide application across the curriculum" (Battalis & Boland, 2006, p. 191).

In response to such apprehension, Fitzpatrick (2001, p. 87) suggests that accelerated uptake and use of GIS in schools will follow from four things:

1. increased teacher experience using computers in general;
2. increased access to ICT hardware;
3. increased adult spatial literacy skills; and,
4. increased public support for "authentic activities".

In 1995, Nellis asserted that the future of geography's success was reliant upon the development of spatial technologies. That view was supported by Salter (1995), who added that the most useful technology in geography will enable the development of skills in spatial observation. Spatial technologies have indeed developed in the score years since Nellis and Salter made their assertions. So too have a range of theories about GIS' potential educational benefits. Yet, the extent to which enhanced spatial technologies such as GIS do actually influence student learning, and the manner in which they will do so, remains unclear. Perhaps greater clarity in these regards would engender geography educators with the confidence to employ GIS in their own learning sequences. The next section of this literature review will address such aspects.

GIS and Student Learning



Because it enables large volumes of non-sequentially related data to be united (Kam, 1996; West, 1998a), GIS can be used as an "integrative tool" that bridges traditional curriculum/discipline areas (Fitzpatrick, 2001, p. 87), a point with which both Gerber (1995a) and Baker (2005) concur. However, to enable students to reach the level of competence to identify patterns of spatial phenomena with GIS, they must first be assisted in mastering basic skills in the use of the software (Baker, 2005; National Research Council, 2006); supporting later, "more elaborate studies" (Fitzpatrick, 2001, p. 85). In this respect, Sui (1995) noted some years ago, and Baker (2005) reminded us more recently, that GIS education essentially involves two aspects: teaching *about* GIS and teaching *with* GIS. The teaching *about* GIS involves students learning how to use it. The teaching *with* GIS involves students using GIS to learn.

This raises an issue associated with GIS. Teachers using it do not control everything that is being learned by students while using GIS (Dascombe, 2006; Gerber, 1995a; Kidman & Palmer, 2006). There are two adjuncts to this. First, students can be empowered to create their own learning experiences and outcomes, with varied consequences. Second, failure to master basic software procedures may limit their capacities to achieve even the most rudimentary of spatial data manipulation (West, 1998a).

Perhaps more promisingly, West (1998a, 2003b) noted that, while using GIS for extended investigation following the geographic route of inquiry, students may proceed through tasks of differing levels of complexity and at rates commensurate with their own levels of both spatial and software literacy. This concurs with Gerber's (1995a) earlier suggestion that GIS allows different students to investigate different issues in different ways, using different sets of data and analysing different combinations of data (e.g., graphs, maps, table, other linked information), generating results that possess a similarly diverse range of output.

The implications of this versatility are discussed by Fitzpatrick (2001). He believes that when students are freed from teacher prescription of GIS tasks, they are able to explore quite a range of relationships, not just the ones intended by the teacher, and not just the ones that the teacher may have deemed most important. Indeed, he suggests, once students move beyond simple data display, their use of GIS allows them to "explore the patterns that appear" independently (p. 86). On this basis, he concludes that "students given the encouragement to explore where their minds and the data allow can wander for away from where the teacher has planned" (p. 86). In more general educational terms, Alexander (2006) believes that the provision of such meaningful choices within tasks empowers, motivates and equips learners, but only when teachers are prepared to relinquish some of the control that they have traditionally held over classrooms. Through such an approach, "greater student engagement, interest and also greater independence and self-direction in thinking [emerge when tasks] are truly open-ended … and the required decision making is more likely to involve students deeply with the content in a way that encourages thinking" (Richhardt, 2002, p. 15).

ESRI prefaced this a decade ago when they emphasised the advantage to teachers of engaging in more risk taking and adopting more of a facilitator role when using GIS (ESRI, 1995). Kerski's (2001) findings were consistent with this, where GIS' adoption was most likely to be by those "who value an open-ended, exploratory approach to learning" (p. 83). Also consistent with this view in general terms were the personal accounts of contributors to the recent Forum section in *International Research in Geographical and Environmental Education* about "Issues Affecting GIS' Implementation in Australian and New Zealand Schools" (see, for example, Beeson, 2006; Brodie, 2006; Kidman & Palmer, 2006; Meaney, 2006; McInerney & Shepherd, 2006)

Possibly because of this, Fitzpatrick (2001, p. 87) observes,

> those teachers who habitually challenge students to go out and forage for knowledge among real-life conditions and experiences are much more likely to engage the full power of GIS. Those teachers who seek the more predictable path and characterise teaching as the delivery of knowledge are less likely to use it effectively.

Furthermore, those teachers who fall into Fitzpatrick's latter group are likely to find themselves avoiding data, hardware and software issues more so than pursuing "the important issues of inquiry process and analysis of the data" (Baker, 2005, p. 48).

On this basis, it is perhaps not surprising that Fitzpatrick also observed that teachers who used GIS most were not those who had the best knowledge of it. Rather, they possessed sufficient small understanding to develop the confidence to establish for students "a visible goal, and then stand back" (p. 87). Or, as a teacher said a decade ago, "Nothing works the first time. Don't get frustrated – go with it and learn with your students. Be amazed at what the students will do that you never in a million years would have thought of" (ESRI, 1995).

GIS and the Route of Geographical Inquiry

As discussed earlier, much of contemporary school geography deals with decision-making (Casinader & Casinader, 1994; Fitzpatrick, 2001; Gregg, 1997; Gritzner, 2002; Howitt, 2002; McKeown-Ice, 1994; Murphy *et al*., 2001). The relationship between decision making and GIS has been discussed by West (1998a, 1999, 2003b). Since decision-making always occurs in the context of uncertainty (Smith, 1993), we cognitively refer to our prior experiences to find a solution or solutions. If our prior experiences have been successful it is likely that, circumstances being similar, we will again be successful. However, the adjunct to this is that if our prior experiences were based upon inefficient thinking processes, then we would likely experience difficulty in reaching success.

This is where heuristics come into play. Heuristics are the generic cognitive strategies that we use to interpret and respond to various situations. For example, when we enter a room full of people, we make sense of what we see by referring to our memory of other rooms that we have entered, and we decide how to act by recalling which behaviours were successful in those situations. How we access those memories determines how efficient we will be in entering the room without embarrassment (presuming that we possess an understanding of socially acceptable behaviours). In this regard, some heuristics of memory search are more efficient than others. For lower level thinking, simple trial and error may be sufficient. Yet, this way of thinking would be much less efficient in situations demanding more cognitive effort, such as those attributes that rate high on Bloom's taxonomy (Bloom, 1956). This hierarchy of thinking skills enables us to identify the level of complexity of various thought processes.

Such higher order thinking is necessary if geographical study is to provide a mechanism by which students may reason both *in* and *with* geography (Gregg *et al.*, 1997, original emphasis). Reasoning *in* geography involves using the knowledge acquired through geographical study to better comprehend geographical concepts. Reasoning *with* geography involves the application of such concepts, and the heuristics associated with them, to other, not specifically geographical, phenomena. Unless "frequent use of higher-level thinking skills" occurs (Macaulay, 1994, p. 23), related to reasoning *with* geography, students may generate neither the additional geographical information nor the spatial insight needed to manage uncertainty and resolve contemporary geographical issues.

However, for higher level thinking to occur efficiently, the information being recalled must have first been configured. Configuration involves the prioritisation of information and its subsequent placement into recognisable groupings (Gregg *et al.*, 1997; West, 1999). In geography, this commonly involves clusters or sequences being derived by attaching meaning to an object's relative or absolute placement (Gregg *et al.*, 1997). For example, a map is meaningless unless its elements have been defined, such as with a legend.

GIS configure data based upon their spatial characteristics. In *ArcView*, data are encoded as Attributes, collectively forming Themes. For example, the Anglican Church and Catholic Church are separate attributes of the theme, Churches. These are more similar to each other than is the High School, which would constitute an attribute of a different theme, say Schools. Alternatively, all three may be clustered as attributes of a single Theme, Buildings. This multiplicity of means of encoding data enables GIS to store large volumes of non-sequentially related data.

Biggs and Moore (1993) recommend that each task needs to be presented in such a way that it enables multiple levels of coding. Within geography education, Robertson (2003) sees that this aspect of the subject "provides the tools for individuals to process the vast quantities of information available, and to be able to build personal geographies in place and space so that multiple realities and complex identities can live harmoniously in the same neighbourhood" (p. 21). Spencer (2005) concurs. Indeed, not only do GIS capabilities align well with the route of inquiry, it is just such an inquiry-based instructional model that Baker (2005, p. 46) calls a "natural fit". Bednarz (2000) agrees. As a tool for the study of geography, GIS not only allows this; its successful use demands that it occurs (West, 2003b). Once successfully configured, data may be efficiently managed and manipulated using GIS. From datum to complex map or chart, GIS handle data in increasing complexity. Table 7 illustrates how this complements both the route of geographical inquiry and Bloom's taxonomy.

Table 7

The relationship between ArcView GIS, Bloom's taxonomy and the geographical route of inquiry (after West, 1998a, 2003b).

Level of Complexity	*ArcView* Functions	Bloom's Taxonomy	Geographical Inquiry
Generating new information	Layout	Evaluation	How Ought?
Spatial analysis	Query Builder / Select By Theme	Synthesis	What Impact?
Data analysis	Chart/View/Query Builder/Select By Theme	Analysis Application	How/Why?
Data	Theme/View/Table of Attributes	Comprehension	Where?
Datum	Attribute	Knowledge	What?

Left-side brackets: *Data manipulation* (Generating new information – Data analysis); *Data management* (Data analysis – Data); *Data encoding* (Data – Datum).

Right-side brackets: *Reasoning in geography* (What Impact? – What?); *Reasoning with geography* (How Ought? – How/Why?).

If the assertion by Gregg *et al.* (1997) that the way that information is taught influences how that information becomes available is correct, then it becomes important to view the teaching of thinking in terms of what is required to enable efficient higher level thinking processes to occur. If efficient heuristics are needed to allow successful evaluation and synthesis, then educators are responsible for teaching the skills necessary for this to occur. From the above discussion, one of the precursors to efficient evaluation and synthesis is the orderly configuration of data. Hence, if GIS provide this type of orderly configuration, it is possible that their use may model this skill for students. In this regard, by reflecting the thinking processes involved in geographical problem solving, GIS could expose students to more efficient heuristics. If, *inter alia*, the successful use of GIS requires the use of these processes, then GIS users are more likely to develop more efficient processes for reasoning in and with geography.

One of the three criteria that Naish *et al.* (1987) devised to justify the inclusion of any subject in the school curriculum is whether it is capable of developing students' skills and capabilities. Through the inquiry process, geographical investigation using GIS requires that students develop a range of skills and an awareness of when to use them. More than a set of computer tools, GIS entail a specific method of its own for analysing the world, and applying spatial data to solving problems. This method, more than tools, make GIS attractive to teachers (Kerski, 2001). We should not, however, focus on developing skills merely for geography's own study, but to contribute to "an education for social competence…not in specialised knowledge" (Piper, 1994, p. 346). Using GIS in geography might just foster skills in social competence by emphasising the importance of encoding information based on spatial characteristics (Kam, 1996), and by manipulating this information to generate new geographical information to devise recommendations for the resolution of issues (Laurence *et al*., 1993; West, 1998a).

GIS and Student Motivation

The other two criteria to justify any school subject devised by Naish *et al*. (1987) are: it should be concerned with a body of knowledge of genuine significance; and, it should open up opportunities for values education.

The use of GIS enables larger volumes of data readily and routinely to be incorporated into learning sequences. The extensive range of real-world data available for manipulation through GIS enables students to study cultural and physical environments at a much broader range of scales than through standard classroom methods. Personal involvement in detailed geographical analyses of issues of personal significance and immediate relevance can also occur. This idea has been discussed widely (see, for example, Baker and White, 2003; McInerney, 2002a, 2002b, 2006; West, 1998a, 2003b, 2006d). Moreover, as a generic tool, information technologies are an integral component of students' lives (Selwyn, 1997). As such, GIS increases the personal and societal significance of geographical study.

In response to the third criterion, one of the core goals of school geography is to inculcate a values-based approach to conflict resolution. Queensland's Senior Geography syllabus, for example, stipulates that its study "will involve a critical understanding of value issues…for to select issues and consider solutions is to make value judgements about what is important and appropriate" (Queensland, 1999a, p.1). In this vein, syllabuses commonly prescribe that students be exposed to actual or hypothetical conflicts arising from human-environment interactions. Their formulation of plausible solutions to such issues requires an understanding of the values underlying the various decisions and actions that contributed to the conflict. If students are better able to engage in the analysis and manipulation of data related to actual conflicts, they may be more comprehensively exposed to the influence of attitudes and political structures upon the decision making processes. Hence, using GIS might afford students the opportunity to develop skills to analyse not simply the geographical data, but also their personal values and attitudes and how they, and those of others, influence those data.

In this regard, West (1998a) hypothesised that the use of GIS in school geography not only encourages intrinsic motivation by providing relevant learning experiences, it better positions geography within the school curriculum (Naish *et al.*, 1987). This idea was investigated further by West (2003b). He surveyed over one hundred students from four subjects in three year levels at two Queensland schools before and after involvement in GIS-related lessons, using a five-point Likert scale with 47 items. This study concluded that using GIS appears to positively affect student attitudes, and for two reasons (p. 270). First, GIS offers students the ability to engage in the development of higher level thinking skills. Second, intrinsic motivation is enhanced by doing this in the context of investigating issues of personal significance. This combination of enhanced perception of relevance and the provision of an appropriate level of cognitive demand suggests that using GIS may positively influence student learning.

GIS and Vocational Opportunity

Technological developments within the fields of geomatics and surveying have greatly changed the manner in which these professions operate. Similarly, the nature of the industry itself is changing (Gewin, 2004; Trinder, 1996). Since a large number of surveyors entered this profession in the 1960s, their exit from the workplace in the past decade was predicted to demand an increase in people skilled in these areas (Skelly, 1996; Gewin 2004). According to Gewin, demand remains strong, with "job opportunities... growing and diversifying as geospatial technologies prove their value in ever more areas" (p. 376). A number of publications during the past decade, have indicated with urgency the need for educators to embrace these trends and reflect this changing nature of technological integration within the spatial sciences (e.g., Baker, 1997b; McInerney, 2002b).

However, technical skills alone are not sufficient (Gewin 2004). Rather, Gewin continues, potential employees require "a deep understanding of underlying geographical concepts" (p. 377). She asserted that the worldwide geospatial market would grow from US$5-billion in 2003 to US$30-billion in 2005; growth due largely to the rapid diversification in the application of GIS technology as a "powerful decision making tool" (p. 376). Citing examples as varied as responding to the recent outbreak of severe acute respiratory syndrome (SARS), fires in southern California, and homeland security, Gewin makes clear the need for employees with both technical and theoretical bases. However, given the requirements of the industry for increasing numbers of graduates with a broad academic knowledge in tandem with spatial technology skills, the role of secondary schools has been surprisingly overlooked (West, 2004a).

In this regard, Johnson (1996, p. 103) a decade ago observed that

> the potential of GIS to the business community is substantial and that, at present, business user definitions of GIS focus on … limited spatial decision-making support. Geographers would appear to have a considerable role to play in responding to, and moulding, this potential through creative curriculum decision-making that reflects a consistent regard for education..., the analytical potential embodied in GIS…, and the communication principles that inform effective GIS design.

Students who have excelled in GIS and another area of study such as environmental, biological or earth sciences tend to move rapidly into employment because their interests and educational credentials are diverse (Gewin 2004; Skelly, 1996). To this, Trinder (1996) offers five guiding principles to prepare students for a career in the spatial sciences:

1. students must receive a broad education;
2. students must be able to analyse and solve problems, and adapt to new technologies and procedures;
3. since demand for traditional skills will decline, students must acquire knowledge of the principles and procedures of spatial data gathering, handling and manipulation, rather than specific detail;

4. assignments and assessments should be project based to encourage students to think innovatively; design should be less for skills development than analysis; and,
5. project management should be presented to allow students to address both organisational and procedural problems.

While this employment is based upon the completion of some tertiary study, high school geography may still play an important role, and for two reasons.

First, there is a shortage of students undertaking the relevant tertiary programs. According to Will Featherstone, former Vice-President of the Australasian Surveying and Mapping Lecturers' Association, this was due to lack of interest amongst the student community; it was not an attractive option for high school leavers (Baker, 1997a, 1997b). More recently, in an email communication on 10 May, 2007, Associate Professor Bert Veenendaal, Acting Head of Department, Department of Spatial Sciences, Curtin University of Technology indicated that "there is still the problem of attracting students largely due to the fact that they do not know about GIS and the opportunities". However, according to South Australian geography teacher, Malcolm McInerney (2002a), secondary students "take to GIS like ducks to water" (p. 42). That students develop positive views of GIS is further evidenced by West's (2003b) finding that their attitudes improved following exposure to GIS-based learning experiences. In response, exposure to and successful use of GIS at school might raise student awareness of the (potentially positive) role of spatial technologies, which may then increase the number of students who consider further (tertiary) study in related fields.

Second, including GIS in high schools readily adopts each of the above five principles. This shall be illustrated through West's (2004a) reference to a Grade 10 project, where students devised a Strategic Plan for the Burdekin Rangelands, the aim of which was to recommend how the region's natural resources could best be managed to sustain the current mix of economic activity.

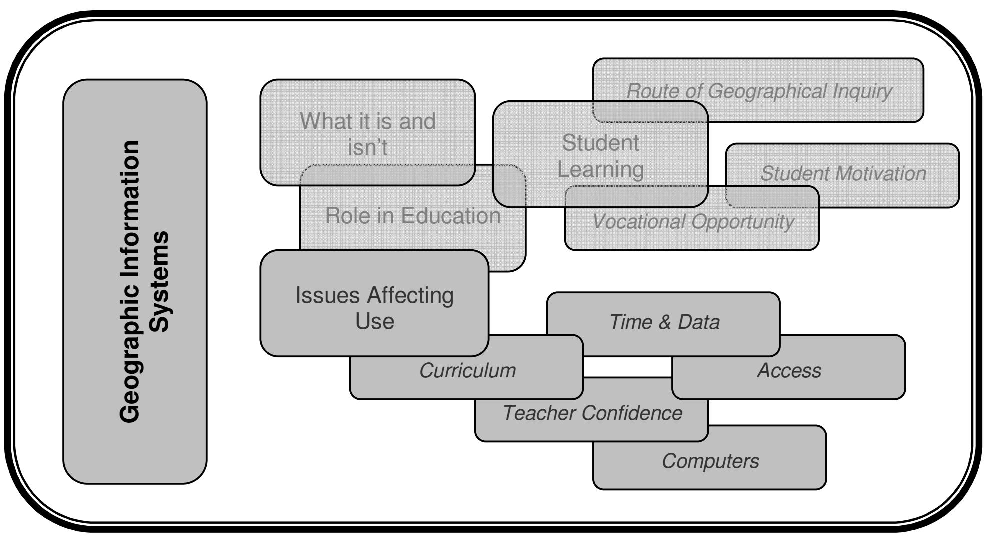
GIS was introduced as an integral component of the investigation. Its competent use became a necessary part of the project, rather than an exclusive outcome, addressing the first principle. Principle Two was met in two ways. With basic information provided, students identified and structured the stages of the project. This required on-going personal assessment of progress and evaluation of the strategies by which problems may be solved. Also, incorporation of various technologies, such as spreadsheets and digital imagery, made the project more efficient. With regards Principle Five, limitations of time and individual ability demanded that students develop project management skills through collaborative decision-making and delegation.

Principles Three and Four were achieved through participation in the subject, rather than simply undertaking this project. For example, within Queensland Senior Geography, wherein multiple methods of data capture and analysis are utilised, students necessarily adopt awareness of the basic principles of data handling. Further, syllabus requirements preclude GIS fluency from providing the sole basis of assessment. Rather, it may be used as a tool by which student performance in a range of assessment criteria is demonstrated. In Senior Geography, these criteria would be Analytical Processes, Decision-Making Processes ad Research and Communication Skills. West (1998a, 1998b, 1999) and Table 6 provide further examples of GIS related learning sequences that address these five principles.

As evidenced by the increasing proportion of (Queensland) students undertaking OP ineligible courses of study (Table 4), there has been an increased emphasis on vocational education and training (VET) and non-traditional pathways within the secondary education sector. This enables high schools to offer studies which, although once the domain of higher education and private providers, may now directly qualify students for credit toward tertiary courses. As with the first point, the likelihood of continuance in a GIS related award beyond school may be greatly increased for the student who has already successfully completed some requirements of that course of study. As an example, McInerney (2002b, 2006) has formalised his curricular application of GIS by developing a GIS-based course which enables students to achieve the skills and methodology of Stage 1 Geography in the South Australian Certificate of Education. While it is yet to occur, it is likely that students who complete this course could, in theory, gain credit toward industry-level GIS training courses offered elsewhere. Thus the potential for Recognition of Prior Learning could apply as equally to GIS-related school activities as it does for other student learning.

Due to the multidisciplinary nature of school geography, it is, arguably, very difficult to teach purely about GIS in a school environment (West, 1998a). This may mean that school students are more likely to also be exposed directly to the multidisciplinary application of GIS' skills (Baker, 2005). Hence, commencement of tertiary study with an awareness of GIS' value may improve the likelihood of students including spatial technologies within a program of broad undergraduate study (West, 2004a). Apart from the potential for enhanced learning, teaching with GIS in schools may thus contribute to redressing the perceived shortage of skilled practitioners within the spatial sciences. However, the extent to which the potential for this, and that of GIS' use in schools generally, may be realised is limited by a number of constraints. It is these which will be now discussed.

Issues affecting GIS use



Many authors laud the potential contribution of GIS to geography education (see, for example, Baker, 2005; Dascombe, 2006; Olsen, 2002; Patterson, Reeve & Page, 2003; Seong, 1996; Smerdon, 2006; Wiegand, 2001). Arguably, this potential may be matched only by the many ways of "doing GIS" in schools (Fitzpatrick, 2001, p. 85). Indeed, this may in itself be partly responsible for limiting its adoption, and why its potential, howsoever lauded, is yet to have more than what Wiegand (2001, p. 68) describes as a "negligible" impact on the nature of geography education within schools. The reasons for this can be loosely grouped into five, overlapping, categories: curriculum; teacher confidence; time and data; computers; and, access. Pun-Cheng and Kwan (2001) found similar classes emerged from their interviews with Hong Kong teachers. Further discussion of issues affecting GIS use generally, and GIS-uptake specifically, is provided by, among others, Audet and Paris (1997), Baker (2003), Beeson (2006), Chalmers (2006), Jenner (2006), Kerski (2003), Lloyd (2001), Meaney (2006), McInerney (2002a), O'Mahony (2003) and Smerdon (2006).

Curriculum Issues

"While the technology continues to change at break-neck speed, the broader classroom environment changes more slowly" (Chalmers, 2002, p. 26). In this regard, the use of GIS is not always compatible with external curriculum constraints (Baker, 2005; Smerdon, 2006; West, 2006d). By way of example, in their "informal discussion" with geography teachers in Hong Kong, Pun-Cheng and Kwan (2001, p. 90) discovered that teachers believed GIS to provide good potential to undertake tasks not otherwise available in the classroom. However, the likelihood of this opportunity being exploited, in Hong Kong and elsewhere, may remain limited until an answer is provided to the question of whether curriculum should be somehow "expanded or modified" to reflect GIS' potential (p. 88).

Limitations of GIS' application within curricula appear to be widespread. In the United Kingdom, reference to GIS was made in statutory curriculum statements in the early 1990s resulting in an "explosion in resource material" (Wiegand, 2001). Since then, Wiegand continues, most teachers have remained "puzzled by what was … an unfamiliar term" and, by 2000, its reference was removed from statutory statements, but remains in non-statutory guidelines, with "statutory or examination board obligations to incorporate GIS into the curriculum" (p. 68).

Recent curriculum development experiences in both the International Baccalaureate Organisation and the (Canadian) Ontario Ministry of Education considered GIS to be “too difficult to impose upon schools” (Hoel, 2003, p. 372). Hoel continues to argue that, whereas interest in including GIS in international curricula is high, its inclusion in the syllabus would “cause an outcry,” and especially so in contexts where even the inclusion of topographical map interpretation was considered optional (p. 372).

While the current Queensland Senior Geography syllabus does include GIS as a resource that can be used to aid in student attainment of its Global Aims (p. 61), and offers its use as a suggested learning experience for some topics of study, the extent to which it can be incorporated beyond a few lessons appears constrained by the criteria against which student performance is assessed, as outlined in Table 2. Despite further statements supporting the use of spatial technologies being made in the revised (2007) syllabus, the existing concerns appear likely to continue unabated (Queensland, 2007c). By way of contrast, the inclusion of GIS in South Australia’s curriculum documents in 2001 catalysed the comparatively widespread uptake of GIS in that state (McInerney & Shepherd, 2006).

At Presbyterian Ladies College in Melbourne, Victoria, early steps to implement GIS have, despite the enthusiasm and commitment of staff, been “difficult in an environment where teachers have to meet a multitude of external, internal and ever-changing curriculum and administrative requirements” (Turner and Beeson, 2003, p. 42). At a national level, in New Zealand, curriculum related programs that integrate GIS into teaching and learning are rare (Chalmers, 2006; Olsen, 2002). Although many schools there have entered competitions, such as the ESRI and AURISA GIS in Schools competitions, few schools have implemented programs that consistently integrate GIS into the curriculum; indeed, Olsen found that, in 2002, only 1% of schools in NZ had a curriculum program in place or being developed that integrated GIS technologies. In simple terms, and representative of many authors from a variety of nations, Pun-Cheng and Kwan (2001) assert that “we need a carefully designed curriculum” and one which answers the question of to what extent “should the high school curriculum also be expanded or modified … in response to this changing technology" (pp. 88, 91)?

Teacher Confidence Issues

The growth in technology in education has presented numerous issues for teacher training. Chalmers (2006) goes so far as to suggest that "the social acceptance of computing has not been matched by the creation of an educational environment that can promote the use of GIS in the classroom" (p. 267). Smaldino and Muffoletto (1997) noted that since the decisions a teacher makes about how to select and integrate technology will influence learning, and since the technology is itself changing, "there has to be a greater understanding of the role of technology in the classroom" (p. 37). These authors further observe, in general terms, that "most teacher education programs struggle with being able to provide a comprehensive program of study," precluding students from gaining "an understanding of the applications of technology in education in the broad sense, with an in-depth examination of how technology supports learning in specific content areas" (p. 37). This continues despite more recent research identifying "high levels of agreement between student teachers and their mentors about the value of ICT as a resource in teaching and learning" (Loveless, 2003, p. 327).

While almost a decade old, the repeated call for further research in to the specific detail surrounding GIS' application within school geography suggests that the concerns of Smaldino and Muffoletto's remain valid: teacher confidence with GIS will influence their use of GIS (Beeson, 2006; Chalmers, 2006; Jenner, 2006; Meaney, 2006; McInerney & Shepherd, 2006; West, 2006d). More generally, Rakes, Fields and Cox's (2006) survey of teachers across 11 (US) school districts revealed a significant, positive relationship between three variables: levels of class technology use and personal computer use and use of constructivist teaching methods.

Of specific relevance to the present discussion, Kerski's (2001) survey of 1500 US schools revealed the characteristics of GIS uptake and impediments to its use. Specifically, Kerski identified teacher experience as significant in determining the extent to which GIS would be used in high schools. The vast majority of US teachers who regularly used GIS were considered both highly qualified and experienced; over 76% possessed tertiary qualifications at Masters or PhD level, and over 60% had taught for more than 15 years. Kerski concluded that GIS was more likely to be implemented by those teachers who possessed both the educational background and time required to devote to it. Although promising that there remains only a "widening interest" in GIS within geography teacher training in Australia, Robertson (2004, p. 174) raises concerns about the likelihood of GIS' broader acceptance within curriculum; a conclusion for which much support can be found (e.g., Baker, 2005; Beeson, 2006; Hoel, 2004). This would appear to add credence to Chalmers' (2002) assertion that inquiry-based learning in the digital classroom is an unrealistic goal for most geography teachers.

Kerski (2001) discovered statistically significant differences between those teachers who "embark on a long-term program of learning about and implementing a complex system such as GIS in the curriculum, [who] must be highly motivated, willing to take risks, and not afraid to experiment with new strategies" and those who are not (p. 73). Interestingly. teachers using GIS tend to be more active in their professional activities, attending more conferences than non GIS-using teachers.

In 1995, Gerber (1995a) predicted that teacher training would become an issue affecting GIS' uptake. Indeed, training is seen by most teachers of geography in New Zealand to be the key factor in determining the extent to which GIS will be used (Chalmers, 2006; Olsen, 2002). However, even though most technology training is targeted at in-service rather than preservice teachers (Bednarz and Audat, 1999), there remains a perception that the training that does occur does not equip teachers to use the technologies effectively in the planning and administering of learning experiences (Baker, 2005; Kidman & Palmer, 2006; Milken Exchange and the International Society for Technology in Education, 1999; West, 2006d).

On the basis of this apparent contradiction, it appears that teacher interest may be the driving factor in the adoption of GIS. Anecdotally, this is something that I observed while editing the recent IRGEE Forum about issues affecting GIS' use in Australia and New Zealand, leading to my concluding statement, as follows (West, 2006d, p. 258):

> That Forum contributors appear to view the benefits of using GIS to outweigh issues surrounding its use is perhaps no surprise. Indeed, a plausible criticism of the collective wisdom presented by this Forum is that it reflects only the experiences of those who have been successful. However, when I consider the experiences that are recounted in the following articles, I find that it becomes equally plausible to suggest that this goes to the very heart of GIS' successful implementation: the sheer enthusiasm to implement it combined with the tenacity to overcome the obstacles that invariably confront any innovation in education.

For example, at Presbyterian Ladies College Melbourne, it was the combination of one teacher's enthusiastic leadership in the areas of curriculum and skills development that motivated the participation of colleagues in demonstrations, workshops and discussions about the application of GIS in the classroom (Turner and Beeson, 2003). On-going training needs at this school are met through a mentoring process which, while expensive, provides the novice GIS-teacher with both software and non-specific IT support to facilitate progress toward their curriculum goals (Beeson, 2006). As suggested in Chapter One, my own experience in the use of GIS in three schools has not been unlike this.

Hence, it appears that a major obstacle to the coordinated adoption of GIS is the absence of coordinated training (Kerski, 2001). Although Kerski found that 17% of GIS-teachers trained themselves, the quality of training undertaken by others has lacked the specificity required to articulate GIS theory into educational practice. And, since most GIS training emphasises teaching about GIS rather than with GIS, both Kerksi (2001) and, more recently, Chalmers (2006) argue it is non-productive given that its application to secondary education requires a specific teaching method that is unfamiliar to most teachers. Because of this, teachers equipping themselves to transmit the "skills and technologies of GIS" to students are likely to fall short of broad educational goals such as "instruction that fosters critical thinking" (Baker, 2005, p. 48).

Time and Data Issues

Entwined with the issue of teacher confidence are those related to time and data. According to Kerski's (2001) survey of the teachers who use GIS in the US, 62% use it for an hour or more outside the classroom per week, and 21% use it at home. This could be because lessons using GIS take more time to prepare than those which involve more traditional learning experiences (Olsen, 2002). Indeed, time for lesson planning is the "chief challenge to implementing [GIS] in the classroom" (Kerski, 2001, p. 79). This view was supported by Hong Kong teachers interviewed by Pun-Cheng and Kwan (2001, p. 91), who agree that removal of issues associated with time constraints would enable GIS' "potential educational impact [to be] immense". Several contributors to the recent IRGEE Forum, mentioned earlier, iterated similar views with the Australian and New Zealand context (e.g., Beeson, 2006; Dascombe, 2006; Meaney, 2006; West, 2006d).

While a decade ago teachers, including myself, may have viewed the burgeoning place of ICTs in education as an opportunity to reduce time spent in planning, time remains an issue for several reasons. First, teacher skill takes time to develop (Jenner, 2006). Second, developing lessons suited to students and curricula takes time (Meaney, 2006; McInerney & Shepherd, 2006). Third, acquiring and managing data takes time (Beeson, 2006). Teachers have made it clear that they required more lesson time to discuss, analyse and interpret data "before [the] effective learning impact [of GIS] can be felt" (Pun-Cheng and Kwan, 2001, p. 91).

Length of time in accessing data is, in many cases prohibitive (Baker, 2005; Olsen, 2002). Since one benefit of using GIS is the potential for greater relevance, it is important to maintain up to date data (Langley, 2001). While initial forays into the adoption of GIS were met with demands for more data

(Chalmers, 2002), this has diminished as increased technology capacity has created what Fitzpatrick (2001, p. 86) calls “an ever-widening flood”. The development of more large data sets has not assisted schools. Whereas large volumes of data may have once slowed data processing (Raubal, Gaupman and Kuhn, 1997), advances in microprocessor technology have largely obviated this concern. Rather, schools just want smaller, well-structured and readily accessible data sets (Baker, 2005; Jenner, 2006).

The nature of available data presents teachers wishing to use GIS with two choices. They can use large data sets with students, focusing on small elements of those databases. Or, they can extract the data that they want, thus generating a new database (Beeson, 2006). Opting for the former takes more time in class, as networks or individual terminals respond to the greater memory demand. The latter requires teacher skill to extract data, and time to manage that data such that it becomes available for student use. Neither is ideal; a third choice thus becomes more appealing: since there is so much data from which to choose, don’t choose any (West, 2006d).

The growing array of data also creates challenges for teachers who have an equally diverse array of possible ways to use GIS (Fitzpatrick, 2001). To cater for this, he continues, “teachers have fitted the technology to their instructional vision, depending on their grade level, subject focus, available hardware, and comfort in teaching with computers” (p. 85). Many GIS users have also discovered the potential that its use makes for collaboration with others. However, while using GIS may make this task more obvious, it in no way makes it easier to do so (Fitzpatrick, 2001; Meaney, 2006).

Although relevant data is becoming increasingly available, its “adaptation to the particular teaching context is an inevitable requirement” (Chalmers, 2002, p. 26). This is because simply displaying data with GIS does not mean that the data have been subject to any form of analysis (Fitzpatrick, 2001), nor has it been considered for its role in developing student spatial awareness. Of interest here is that Pun-Cheng and Kwan (2001) discovered many Hong Kong teachers perceived that the product of GIS analysis was embedded within the dataset, simply waiting to be retrieved.

To help address this, it may be necessary for teachers not just to prepare data that can generate interesting looking maps, but to develop data sets which enable visualisation competency to be developed, for them *and* their students. Gerber (1995a) suggests that doing this arises from knowing how maps are normally read, and knowing the standard conventions of cartography. By choosing data which can produce maps that allow this knowledge to be developed, he states, teachers can assist students in understanding the maps that they produce using those data.

Since there is very little analysis within a standard GIS package, it is unable to provide solutions to spatial issues by itself (Langley, 2001). Rather, as Langley continues, it simply and clearly displays the data that have been manipulated by the user. Hence, it is up to the user to make meaning out of the data displayed. The need for software competence has already been discussed. To this, it may be possible that difficulties associated with developing the software skills to select and manipulate data may not be as great as the difficulties associated with developing the skills needed to understand and make meaning of that data. When combined with issues surrounding computers themselves, teachers can face very real impediments to using GIS.

Computer Issues

A major issue influencing GIS use in schools is the level of technical support and appropriate resources. 74.2% of schools using GIS possessed technical support, with a chi-squared test by Kerski (2001) indicating that the amount of technical support is significantly higher for teachers using GIS than those who do not. Evidence that this remains the case in Australia is provided by Beeson (2006), Jenner (2006), Meaney (2006) and McInerney and Shepherd (2006). Kerski (2001) further noted that GIS use is more affected by insufficient support and hardware than other software commonly used in schools. Specifically, unreliable networks and hardware are likely to make it difficult for teachers to proceed with confidence in the development of comprehensive programs that use GIS (Olsen, 2002).

As with many technologies, a teacher needs to have an alternative plan if the GIS lesson does not go to plan due to hardware/networking constraints/obstacles. However, the very purpose for using GIS is to provide a learning experience that is difficult, if not impossibly impractical, to emulate without the use of technology. Furthermore, within the actual GIS lesson, the data handling potential of GIS may itself present an obstacle to learning, where the GIS and/or data being used may present a technological demand that exceeds the level of hardware possessed by the school. Reviewing the US situation, Bednarz (2004) concluded that "the programs available for school use ..., essentially the same powerful, full-capacity software used by professionals in the field, are a barrier to implementation" (p191). There is no doubt that GIS demand large volumes of memory and space (Baker, 2005; Kerski, 2001; Table 5). Since not all schools possess the facilities to manage this efficiently, the potential for student disengagement becomes pronounced; and, with it, may come a variety of unintended outcomes (West, 1998a, 2006d).

Kerski (2001) also found that more teachers use GIS on a classroom computer (46.3%) than in a laboratory of computers (27.1%). However, his analyses also revealed that schools that lacked computer laboratories experienced the greatest difficulty in integrating GIS (p. 78) and, since access is generally proportionate

to hardware stocks within a school, any limitation of access will increase the relative cost of both hardware and software needed to support the use of GIS; ultimately deeming it prohibitively expensive (Gerber, 1995a).
Most schools using GIS rely on off-the-shelf products (Baker, 2005; Dascombe, 2006; Kerski, 2001). Of the three main software packages, *ArcView*, *MapInfo* and *Idrisi*, only *ArcView* is available on both Windows and Macintosh platforms. This perhaps explains Kerski's finding that a significant difference exists between the operating systems of schools that do and do not offer GIS education.

Access Issues

Interrelated with computer issues are issues of access. Presuming that adequate computer resources exist to support use of GIS, the lack of regular and reliable access to the hardware that support GIS precludes progress towards its adoption (Olsen, 2002). [As will be discussed later, such access is particularly important since, arguably, mastery of basic functions requires repetition].

Olsen indicates further that, in New Zealand, the widest possible estimate of GIS use is 8% of schools, of which a quarter possess the software but are not using it or are unlikely to use it in the near future. This reflects the US situation, where less than 5% of schools possess the technology, with less than half of those who possess GIS likely to use it (Kerski, 2001).

In the US, the proportion of students in any one school who use GIS reflects the proportion of teachers who use GIS; most schools have only one teacher using GIS; in 42% of schools, 10% of students were using GIS, in comparison to the zero number of GIS-using students in 29% of schools (Kerski, 2001). Such data is yet to be published for Australia.

Apparent from this brief discussion is that there are significant influencing factors in the adoption of GIS. While his US study concurs, Kerski also noted that teachers viewed the benefits of using GIS to outweigh issues such as the five discussed here. Indeed, this apparent optimism is mirrored across the reviewed literature. In light of this, it is appropriate to now identify those questions whose answers may better clarify the role of GIS in contributing to a geographical education.

Questions Arising from the Literature

The preceding review of literature identifies the value of geography within the curriculum and desired features of a geographical education. In considering the potential role of GIS in a geography education, however, it also reveals a dearth of data. Whether or how using GIS enables students to attain the goals of geography remains largely unknown. While some research has suggested positive relationships between GIS use and student attitudes, the way that GIS might assist students to achieve many of geography's seemingly fundamental attributes is not sufficiently clear.

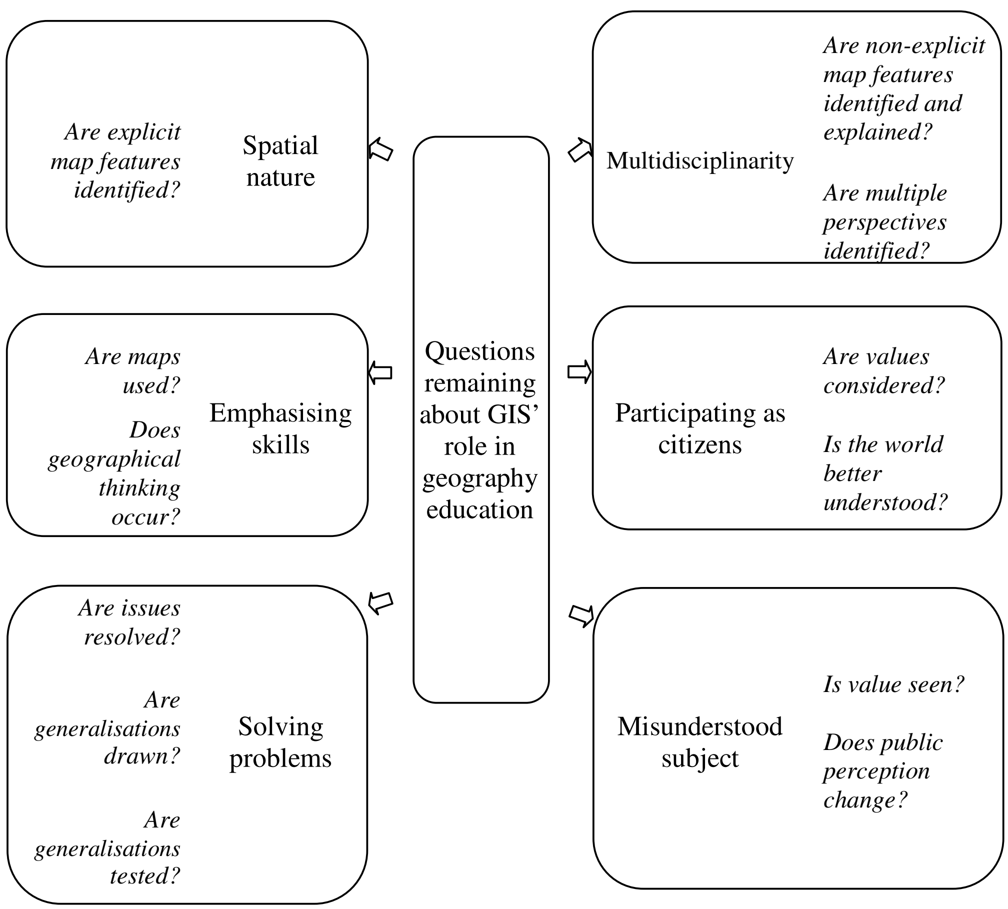


Figure 6. The major features of geography education about which GIS' role remains uncertain.

In this regard, specific questions remain to be answered. These relate to how GIS contributes to each of the major features of geography (Figure 5). With regard to geography's spatial nature, it is not known whether, while using GIS, students use maps to create an understanding of space by identifying explicit features on a map, such as location and distribution.

In terms of its multidisciplinarity, it is not known whether, while using GIS, students integrate information from a map to identify patterns/relationships that are not explicitly labelled. In this way, do they develop an awareness of pattern, trends and land-people interactions? Further, do students, while using GIS, analyse information to determine reasons for these trends and patterns and/or make inferences by linking mapped features to other knowledge and draw conclusions about the map's features? Perhaps more broadly, do students identify the multidisciplinary perspectives of the issues that they are studying with GIS?

In terms of its emphasis on skills, it is not known whether, while using GIS, students use maps to investigate, record and analyse processes arising from people-environment interactions, nor whether they think graphically, by engaging in skills of information processing, reasoning, inquiry, creative thinking and evaluation.

In terms of its emphasis on problem-solving, it is not known whether, while using GIS, students resolve issues using the geographic route of inquiry, nor whether they draw generalisations from data analysis (induction) and/or test generalisations using these data (deduction).

In terms of its role in developing student capabilities for citizenship, it is not known whether, while using GIS, students consider values linked to phenomena being studied, nor if they are engaging in learning experiences which enable them to better understand the world that they live in.

In terms of Geography being a misunderstood subject, it is not known whether, while using GIS, students see value in subject Geography, nor whether public perception of the subject changes as a result of GIS being used.

Central Phenomenon and Research Questions

Three points are evident from the preceding discussion. One, it is evident that geography is a worthwhile inclusion within school curricula. Two, it is evident that for geography's goals to be realised attention needs to be paid to how it is taught and the tools that are used to do so. Three, it is evident there is little known about how to teach with one of these tools, GIS, within geography education.

Whereas both academics and students have identified the benefits of a geographical education, the same cannot yet be said about GIS. A clear directive thus emerges: it is appropriate to identify research that may constitute a 'starting point' and lead to a clearer understanding not just of GIS' role within geography education, but also of appropriate directions for future investigations into how to teach using it.

On this basis, the central phenomenon that has emerged from this review of literature is student conceptions of GIS. The specific research question being investigated is:

> *What are the conceptions of geographic information systems (GIS) held by Senior Geography students?*

The answers to this question may contribute to:

1. Knowledge of the spatial understandings held by students of geography;
2. Understanding of how students gain an understanding of spatial phenomena of varying levels of complexity;
3. Awareness of the potential educational outcomes associated with using GIS;

4. Current discussions about the merit of using ICTs in education, with specific emphasis on the use of GIS in geography education;
5. Decisions related to current and potential geography curricula; and,
6. Understanding how the subject Geography is and can better be understood.

The methodology and research design used to investigate the research question will be addressed in Chapter Three, *Investigative Framework.*

CHAPTER THREE

INVESTIGATIVE FRAMEWORK

Overview of the Chapter

The purpose of this chapter is twofold. First, it will present a discussion of the issues surrounding the adoption of the approach chosen to undertake this investigation: phenomenography. This discussion will consider: the selection of an appropriate epistemology; the central assumptions of phenomenographic inquiry; the determination of categories of description; the delineation of conceptions from within these categories of description; and, the emergence of an outcome space that depicts the relationships between and among these conceptions.

Second, it will present and justify the specific applications of the method to be employed in this empirical research. It will outline the specific considerations for the collection of data to answer the research question:

> *What are the conceptions of geographic information systems (GIS) held by Senior Geography students?*

This will occur in two sections. First, by describing the method of collecting data to answer the research question: synergetic focus group interviews. Second, issues associated with the ethics and trustworthiness of the research outcomes will be presented, and strategies for their mitigation will be outlined.

Summary of methodology

Epistemology

Research involves systematically investigating questions or problems with a view to discovering answers or solutions. In general terms, research can be classed as nomothetic or ideographic (Figure 7). Nomothetic approaches to research reflect the scientific empirical tradition, and strive to identify general principles. Idiographic approaches to research reflect the naturalistic phenomenological mode, and strive to identify individual experiences of phenomena. Further discussion of the two approaches is offered by, among others, Burns (2000), Eisner (1993), Faux (2002), Fraenkel (1995), Grice (2004), Ramsdem (1985), Shulman (1984) and Thomae (1999). Since the central phenomenon of this research is student conceptions, it is appropriate to employ an idiographic approach.

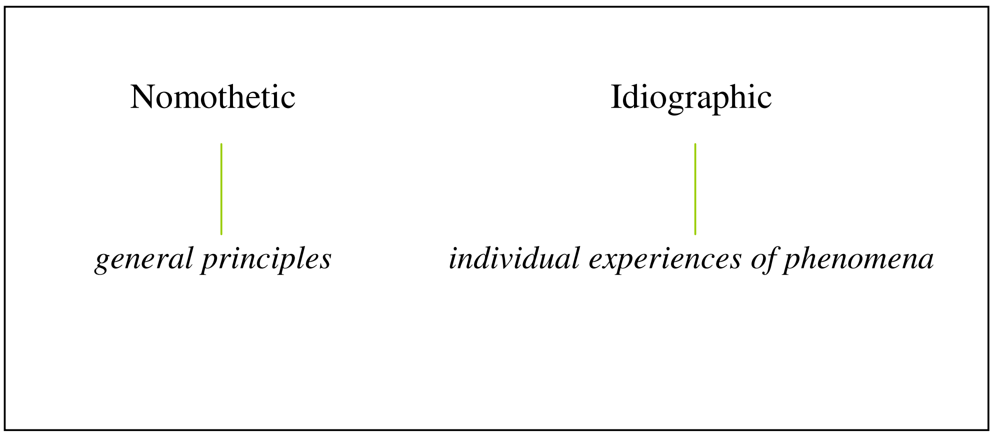


Figure 7. Two approaches to research, and their emphases.

The theoretical approach to research design is informed by epistemology. The epistemology underlying any research can be classified as either quantitative or qualitative. Discussion about these differences is provided by, among many others, Bryman (1984), Creswell (2002), Faux (2002), Firestone (1987), Howe (1992), Howe & Eisenhart (1990), Onwuegbuzie & Daniel (2003), Sale, Lohfeld & Brazil (2002), Smith (1983, 1986), and is further explored in Figure 7 and Table 8. Quantitative research is used to describe and explain general trends and patterns between or among variables. Qualitative research is used to explore an understanding of a central phenomenon. Arminio (2002) explains the difference in terms of the view held by the researcher toward the acquisition of knowledge. He states:

> Quantitative work is based on epistemological objectivism (truth is to be discovered and measured) whereas qualitative work is based on

epistemological constructivism (knowledge is created through engagement with the world) and subjectivism (knowledge is imposed by the researcher by critical examination of textual evidence).

Table 8.

Difference between quantitative and qualitative approaches to research (after Creswell, 2002, pp. 50-58).

	Quantitative Approach	**Qualitative Approach**
Assumes that knowledge is:	▪ To be discovered and measured	▪ Created through engagement with the world
Useful for:	▪ Describing trends ▪ Explaining relationship among variables	▪ exploring and understanding a central phenomenon
To do this, the researcher:	▪ specifies narrow questions ▪ locates/develops instruments to gather data to answer the questions ▪ analyses numbers from the instruments using statistics	▪ asks participants broad, general questions ▪ collects detailed views of participants in the form of words or images ▪ analyses information for description and themes
Using the results, the researcher:	▪ interprets the data drawing on prior predictions and research studies	▪ interprets the meaning of information drawing personal reflections and past research
Report of findings:	▪ is presented in a standard format ▪ displays researcher's objectivity ▪ displays researcher's lack of bias	▪ is presented in a flexible format ▪ displays researcher's biases ▪ displays researcher's thoughts

The extent to which knowledge created through qualitative inquiry is regarded as constructivist or subjectivist depends on the precise approach to qualitative research that is adopted. This distinction was explored four decades ago by Polanyi (1967, p. 33) who described knowledge as "rooted in acts of comprehension", rather than being based on verifiable fact (Maddox, 1993). In this regard, the constructivist epistemology recognises knowledge as constructed within a context (Kennedy, 2004). Schwandt (2003, p. 305) captures the sense of this when he observes that:

> most of us would agree that knowing is not passive – a simple imprinting of sense data on the mind – but active; that is, mind does something with these impressions…in this sense, constructivism means that human beings do not find or discover knowledge so much as we construct or make it.

It is, here, worth recalling that the central phenomenon of the current research is student conceptions of GIS. In this respect, it is appropriate to select a methodology that is grounded in the constructivist view. Kennedy (2004) offers an overview of this relevance through reflection on her own research in the area of knowledge management; wherein the constructionist epistemology led to

> a research topic that recognised knowledge as constructed within a context; the literature's reflection of constructivist theory meant that the research must aim to reflect individual's constructions of meaning; knowledge as an activity of interdependent people meant that the research must allow knowledge to emerge through the interaction of individuals in their sense making; the collective mind directed the research to the understandings and practices of collectives; and complexity theory demanded an approach that was undirected, iterative, drew on diversity, was social, influenced by context and facilitated emergence of novel characteristics.

The specific research question for this study asks: what are the conceptions of geographic information systems held by Senior Geography students? Thus, the research will seek to explore student experiences of a given phenomenon, GIS.

For this reason, a qualitative ideographic, and constructivist, epistemology is most appropriate.

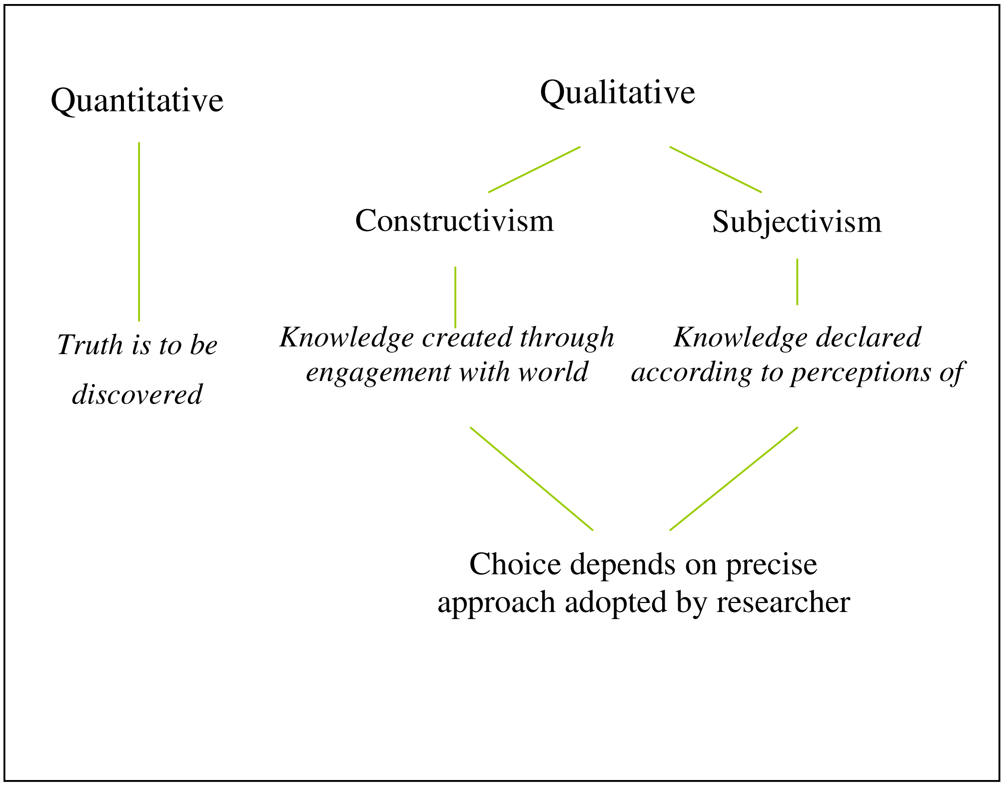


Figure 8. Quantitative versus qualitative approaches to research

Phenomenography: A research specialisation

The epistemology grounds the methodology. Arminio (2002) describes the methodology as “the approach, plan of action, process, or design lying behind the choice and use of particular data collection methods”.

The method chosen to answer the research question has predominantly been drawn from reference to Arminio (2002), Booth (1997), Breen (1999), Bruce (1992), Keyes and Orr (1995), Lindblad (1983), Marton (1981a; 1981b; 1986; 1994), Pinnock (2003), Pramling (1994), Richardson (1999), Sandberg (1997), and Willmett and Lidstone (2003).

To identify the most appropriate methodology for this study it is useful to delineate between first and second order perspectives, as they relate to the investigation of phenomena (Figure 8). Investigations of a first order perspective aim to describe aspects of the world; investigations of a second order perspective aim to describe people's experiences of aspects of the world (Marton, 1981a). Studying the latter, second order, perspective allows people's experiences of phenomena to be described in qualitatively different ways (Marton, 1981b). It is here, according to Pinnock (2003) that the value of such inquiry is found, where an understanding of student conceptions can help the teacher to find ways of achieving specific learning outcomes.

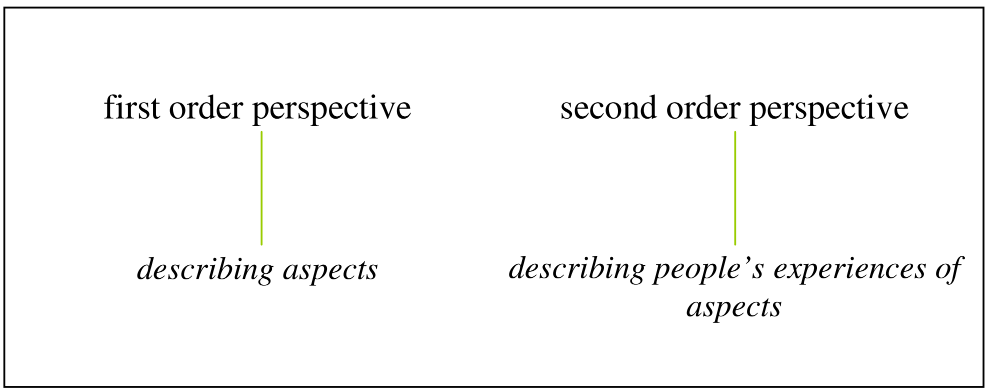


Figure 9. First and second order perspectives, as they relate to the investigation of phenomena.

Phenomenography is a research specialisation that developed "to study human understanding of specific phenomena" (Marton, 1994, p. 253). Willmett and Lidstone (2003) cite Prosser and Trigwell's (1997) assertion that its central assumption is "that there is a variation in people's experiences of the same thing". Moreover, by emphasising the relationships between subject and object within a specific context, phenomenography offers a distinctive relational nature (Bruce, 1995). In this regard, phenomenography fundamentally "accepts that people develop their knowledge of the world through personal experience…all knowledge is subjective in nature" (Gerber, 1992b). It is qualitative research that aims to "elicit and interpret people's interpretations of the world around them" (Breen, 1999, p. 2). It accomplishes this by focusing on discovering patterns or regularities in people's conceptions of certain phenomena (Keyes & Orr, 1995).

Marton (1981a) adds that the phenomenographic approach to research aims to "describe, analyse and understand how individuals conceive different phenomena in the world around, ie, to describe phenomena as they appear to the individuals".

Conceptions

Phenomenographic research strives to "distinguish and describe variations in perceiving or experiencing phenomena in or aspects of, the world around" (Pramling, 1994, p. 227). Booth (1997) concurs, agreeing that these descriptions are of the "qualitatively different ways in which particular sorts of people understand a phenomenon, or experience some aspect of the world" (p. 135). For an individual, the conception is the reality; the term 'conception' has a specific meaning in phenomenography theory that is different in its use elsewhere. In terms of phenomenography, a conception is deemed to be a way of seeing something, a relationship between an individual and a phenomenon (Johansson *et al*., 1995; Figure 10). Because of this, phenomenographic research yields results that offer alternate descriptions of people's conceptions of a range of phenomena (Bruce, 1995; Lindblad, 1983). Further discussion is provided by Bruce (1992, 1997), Marton (1986), Pramling (1994), and Sandberg (1997).

Methodologically, phenomenography relies upon the discursive accounts of participants (Richardson, 1999). This reflects the phenomenographic view that language is a "device for representing the world" (Ekeblad, 1995). Gerber (1995b) captures the foundation of phenomenography with his statement that people's experiences of phenomena "are recorded in the words of other experiences by the participants in a specific context" (p. 1). Because of this, he further argues that interview transcripts can be analysed by phenomenographic researchers to detect the "qualitatively different variations in the [interviewees'] experiences" (p. 1).

All data coded transcripts are treated as "verbal protocols of subjects engaged in a complex reasoning task" (Bausmith and Leinhardt, 1998, p. 96). Bruhn (1989) suggests that qualitative analysis of such data as discourse may, in many ways, serve the functions traditionally performed by statistics in quantitative analyses.

Here, discourse analysis allows the variation in experiences of the participants to be revealed, which, Gerber (1995c) claims, enables this methodology to "adopt a supra-individual orientation in the investigation of human experience" (p. 1).

"It is as relations between the individual and his or her world that conceptions appear" (Ahlberg, 1992). Thus, the *aim* of phenomenography is to describe; the *kind* of objects being described are conceptions (Svensson, 1997) (Figure 9). These conceptions can be defined as ways "of seeing something, a qualitative relationship between an individual and some phenomenon" (Johansson, Marton and Svensson, 1985, p. 235).

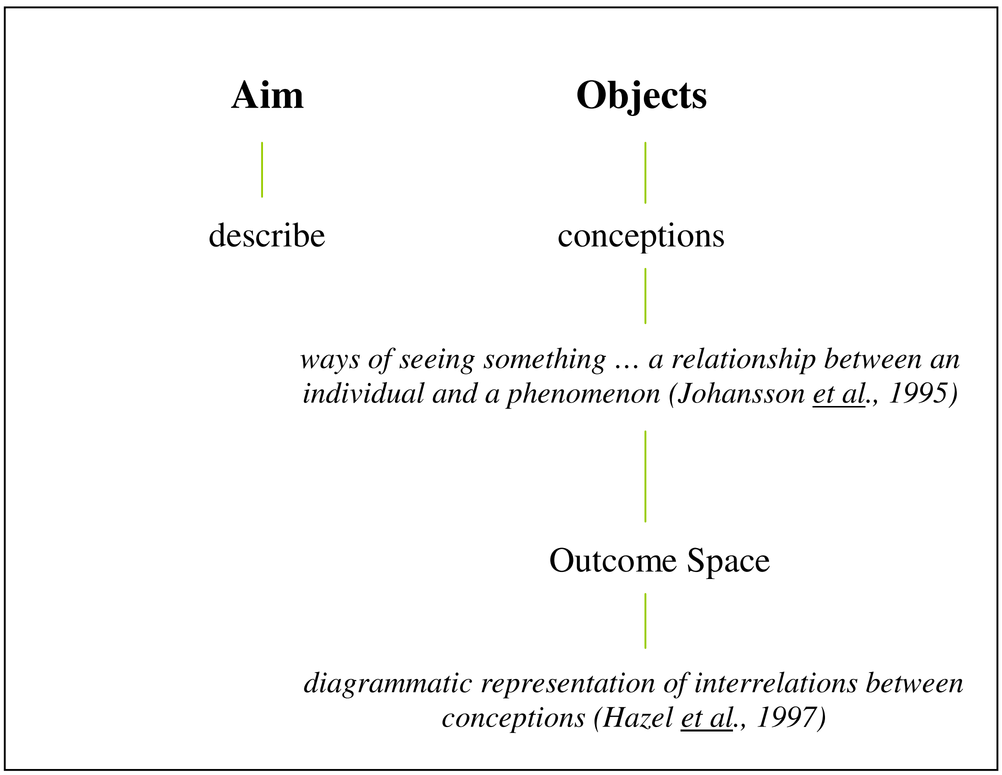


Figure 10. The aim and objects of phenomenography (after Svensson, 1997).

Categories of Description

Conceptions are distilled from within categories of description, wherein the results of phenomenographic research are "presented as carefully described and qualitatively distinct categories in which are captured individuals' conceptions of the phenomenon in focus" (Ahlberg, 1992). However, the phenomenographic approach does not presume conceptions to be individual qualities. Rather, they are considered to be categories of description, which may "facilitate the grasp of concrete cases of human functioning" (Marton, 1981a, p. 177).

Säljö (1994) has called for clarification in the way in which categories of description denote conceptions. To this, Bowden (1994) asserts that categories of description should not be equated with conceptions. Rather, categories of description are to be determined by discerning commonalities in student conceptions of the phenomenon being discussed (Keyes & Orr, 1995). Eklund-Myrskog (1996) clarifies the process, indicating that, when we compare "the similarities and differences between individuals' utterances, these are categorised in such qualitatively different categories, which finally define a category system". The results of phenomenographic research can thus be considered in terms of relationships between conceptions which are distilled from the categories of description: "since some categories of description appear in different situations, the set of categories is thus stable and generalisable between the situations, even if the individuals move" (Marton, 1981a, p. 177).

Outcome Space

Lindblad (1983) further argues that, in phenomenographic research, it is necessary to "distinguish between what is conceived of a phenomenon and how this phenomenon is conceived". For this reason, Hazel, Conrad and Martin (1997, p. 213) note that a critical feature of phenomenographic investigation is the generation of an "outcome space". This reflects the integration of different ways that people "understand and conceptualise the content of specific problems" (Ahlberg, 1992). Renström, Andersson and Marton (1990) similarly describe the outcome space as a system that illustrates the logical interrelations between the "different conceptions, their varying internal structures, and the alternative forms of conceptions found" (p. 555). Hence, from investigating the "most distinctive feature that differentiates alternative ways of understanding a phenomenon …[an outcome space can be developed that]...is a visual or diagrammatic representation of the categories of description which illustrates the relationships between them" (Bruce, 1992, p. 45).

The current research problem may be investigated within the qualitative paradigm (Lancy, 1993). Since phenomenography is a "research specialisation aimed at describing conceptions of the world around us" (Marton, 1994), it is an appropriate methodology for the current study; enabling student conceptions of GIS, and the relationships between them, to be identified and described. Categories of description will emerge through discursive analysis; conceptions will be distilled from within these categories of description; and, an outcome space will be generated, thus presenting a tool that "captures and communicates the features of [those] conceptions" (Bruce and Gerber, 1996, pp. 5-8).

Summary of Method

The techniques and procedures adopted to gather data are collectively known as the method (Arminio, 2002). This section will outline the method used to collect data related to the research question. It will then include consideration of ethics, trustworthiness and design limitations associated with the method.

Understanding the Context: Conversations with Teachers

Conversations were held with staff at each school to identify the specific contexts in which the participating students had gained their lived experiences of GIS. These were held with staff from each participating school who were involved in teaching Senior Geography with an element of GIS. To gain a broader understanding of the context in which GIS was incorporated, Heads of Department were also invited to participate (for two of the schools, the teacher of Senior Geography was also the Head of Department).

The information gleaned from these conversations related to two aspects of each school:

1. The specific characteristics of each school, including details of: its location, demographic composition and curriculum; the place of GIS within its curriculum; teacher expertise in the use of GIS and their attitudes and perceived impediments to its use in the school; and, the technical and other support for the use of GIS.

2. The specific characteristics of the participants from each school, including details of: the number of participants from each year level; the proportion of OP-eligible and OP-ineligible students; the proportion of male and female students; the number of participants in each interview; conditions surrounding the interviews; and, if needed, any teacher comments about any aspect of their students' participation.

These conversations were scheduled for the convenience of staff involved, and were undertaken before, during and subsequent to attending schools to interview students.

Data Collecting: Conducting Interviews

The interview is a critical element of phenomenographic research (Gerber, Kwan & Bruce, 1993). To this, Willmett (2002) cites Crotty's (1998) three considerations for interview design: the nature of the interview; the interviewing techniques; and, the setting for the interview. Bruce (1994b) further explores the particularities of interviewing within phenomenographic research, delineating its distinctive aims, focus, design, role of the interviewer and implementation. Following the theses of Costin (2000) and Willmett (2002), discussion of the method that was employed by the current study will follow Bruce's structure.

The distinctive aims of the interviews

The purpose of the interview is to create a "natural extension of the [established] social relationships" (Burns, 2000, p. 411). Specifically, the aim of the interviews was to explore participants' various understandings of the phenomena of GIS.

The interviews revealed these understandings by providing for the discursive exploration of participant experiences of GIS, from which categories of description could be established.

The focus of the interviews: Synergetic Focus Groups (Talking About GIS)

Traditional focus group interviews gather data from participants who are guided through discussion of set topics (Crotty, 1998). This allows rich qualitative data to be elicited from respondents (Marton, 1986). The advantages of these focus group interviews have been discussed by, among others, Anderson (1990), Crotty (1998), Lidstone (1996), Willmett & Lidstone (2003), and Wilson (1997). However, in synergetic focus groups, the facilitator removes himself/herself from the discussion or from directing the discussion and encourages the open exchange of views from the participants. Thus, by allowing participants to engage in a discussion that is not predetermined, the use of synergetic focus groups provides a number of additional benefits. This distinction between traditional focus groups and phenomenographic focus groups is addressed by Willmett and Lidstone (2003):

> while a phenomenographical approach to research requires that participants explore the outer perimeters of their understandings, the security provided by the group data collection methods provides a non-threatening environment in which such revelations may be made.

A major strength of synergetic focus groups is the twofold potential for participant discussion of issues that have been unanticipated by the researcher (Anderson, 1990) and "considerable potential to encourage conversations" (Willmett & Lidstone, 2003). Krueger and Casey (1994, p. 34) add that they are a "socially oriented research procedure" wherein participants can both contribute to and be influenced by the dynamism of group interaction. Participants can explore their own qualitatively different conceptions, thus enabling an open and deep discussion of "the phenomena which are seen, experienced or understood" (Bruce, 1994b, p. 50). Willmett and Lidstone (2003) succinctly capture the thoughts of several authors who "promote the advantages of free ranging discussions among members of the group where a moderator plays a minimal role".

Although the interview is "a crucial instrument for data collection" within the phenomenographic research specialisation (Francis, 1993, p.68), Säljö (1993, as cited in Breen, 1999, p. 3) observes the need to ensure "a shared communicative context" between all people involved in an interview. To achieve this common understanding between interviewer and interviewee/s, the interview may be preceded by either posing problems, or "by referring to shared topics of discourse" (Breen, 1999, p. 3).

In her study of the conceptions of History held by 17 year old students, Costin (2000, p. 155) noted that commencing her interviews with a "what is…" question was "threatening as a starting point in the interview". For this reason, it is appropriate to commence a synergetic focus group with an introductory monologue (Le Bhers, 1998). Following the recommendation of Skrzecynski and Russell (1994), the introductory monologue in this study: welcomed participants and assured them of confidentiality; advised participants of the purpose of the interview and the meaning of relevant terms; and, introduced the topic for discussion by presenting "a wide range of ideas which are not confined to those that the researcher sees as appropriate" (pp. 369-70). To ensure consistency across groups, the introductory monologue was written, and was crafted to prompt "participants to speak openly in a consenting environment" (Le Bhers, 1998, p. 44). Based on personal experience of conducting synergetic interviews with students of this age (see, for example, West 2003a, 2006a, 2006c), and following the method of Irvine (2005), a series of open-ended prompts was designed to motivate students to reflect on and describe their experiences of GIS. This step both aligned student discussion to the central phenomenon and elicited from them the referential and structural elements of their conceptions. Both introductory monologue and open-ended prompts are included as Appendix G and Appendix H, respectively.

Following the advice of Willmett and Lidstone (2003), a number of considerations were addressed to ensure an environment commensurate with free discussion and reliable data collection. First, students were provided with comfortable seating and individual tables, and systems cards and pencils for note-taking. Second, two recording devices were used, with microphone extension cables allowing the tape recorder to be operated without distraction to participants. All students agreed that their conversation could be recorded.

The role of the interviewer and Implementation of the Synergetic Focus Groups

It was important for the interviewer to plan the interview structure and approach to ensure that it led the discussion in certain directions (Costin, 2000). However, the level of structure was not to an extent that it undermined the benefits of synergetic focus groups; where, as discussed above, they allow for the emergence of issues about which the interviewer is unaware (Willmett, 2002). In this regard, and following the recommendations of Creswell (2002), the researcher's role in interviewing students about their conceptions of GIS involved consideration of nine steps. An abridged version of these is illustrated in Table 9. These steps guided the development of the specific activities undertaken within this investigation.

Participant Selection

It was essential that the selection of participants allowed data to be collected that related to the central phenomenon and research question. Given the emphasis of this research upon student conceptions of GIS within a specific context, it was appropriate to ensure that the participants reflected natural groupings that would either exploit or support that context. In this regard, Burns (2000) recommends "choosing a naturally existing unit [or units] that the participants may see as distinct, and which the observer recognises has a distinct identity of its own" (p. 462).

Given this requirement, a non-probability sampling method was considered the most appropriate. Specifically, an opportunity sampling strategy was employed. While some may argue that opportunity sampling may preclude the possibility of generalisation to a wider population (Atkinson, Coffey & Delamont, 2003; Walters, 2001-02), it did allow for the emergence of student conceptions of GIS. Furthermore, it capitalised upon the existing educational-social context of the participants.

In light of this, the research involved ten groups of students, each comprising between four and fifteen participants; while standardised group size was intended, this was not possible within the school contexts in which the interviews occurred. Each group studied Senior Geography at a Queensland school at the time of data collection and had been exposed to the use of GIS as part of their geography education. The schools from which the sample groups were drawn reflect a range of educational contexts: public and independent, co-educational and single sex, and urban and regional. A detailed description of participants and the contexts in which they both experienced GIS and were involved in this research is provided later in this chapter.

Table 9.

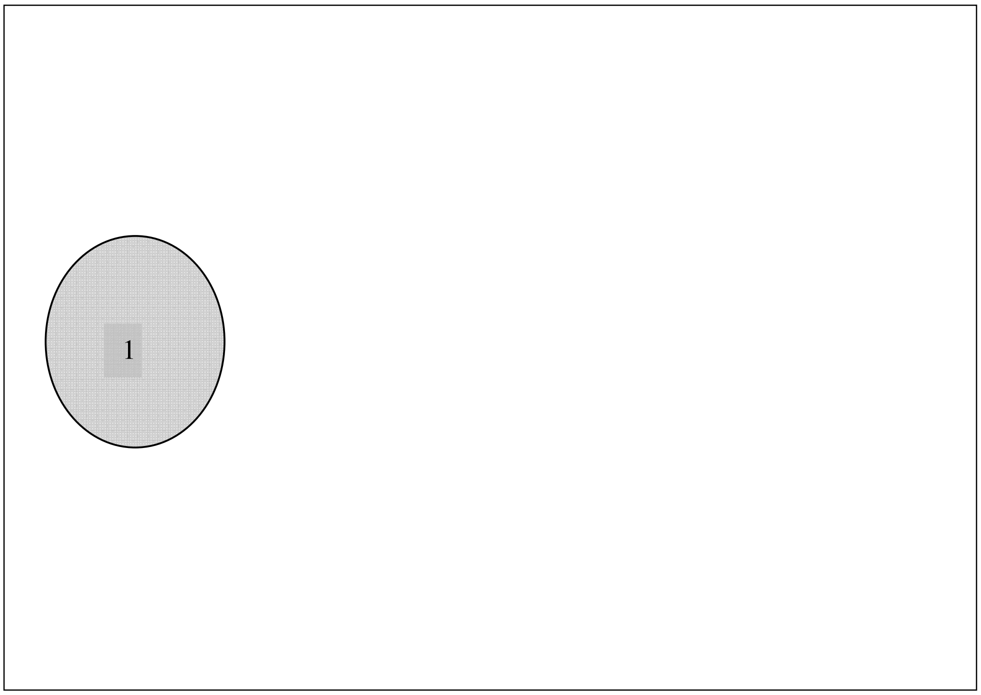
Nine steps involved in conducting interviews (after Creswell, 2002, pp. 207-209).

No.	Step	Description
1	Identify the interviewees	• Determine the most appropriate sampling strategy to achieve the research aims
2	Identify the type of interview	• Determine the most appropriate interview format to answer the research questions
3	Audio-tape the entire interview	• Ensure that an accurate recording of the conversation is undertaken. • Use recording equipment suitable for both site, type of interview and participants
4	Locate a quiet, suitable place for conducting the interview	• Select a site that is likely to present minimal distraction and is suited to audio-recording.
5	Obtain consent from interviewees	• Have each interviewee complete an informed consent form before commencement (Appendix F) • Prior to commencement of each interview, convey to participants the purpose of the study, the intended duration of the interview, the intended use of results and the availability of those results once completed
6	Take brief notes during the interview	• Record notes and observations using an Interview Protocol • Use an abbreviated form of note-taking to increase the proportion of the conversation that is recorded in this form
7	Have a plan, but be flexible	• Adhere to intended plan during the interview, but allow participant conversation to proceed unimpeded
8	Use probes to obtain additional information	• Use probes (classifying and probing) to elicit more information about each question, to clarify points or ideas expressed by participants
9	End and exit the interview	• Thank the participants, assuring them of the confidentiality of their responses, offer to provide summary of results once completed

Analysis: finding and describing categories of description

The analysis proceeded through five stages, reflecting Willmett's (2002) condensed version of Dahlgren and Fallsberg's (1991) process. These stages are described individually.

Stage 1. ***Familiarisation***

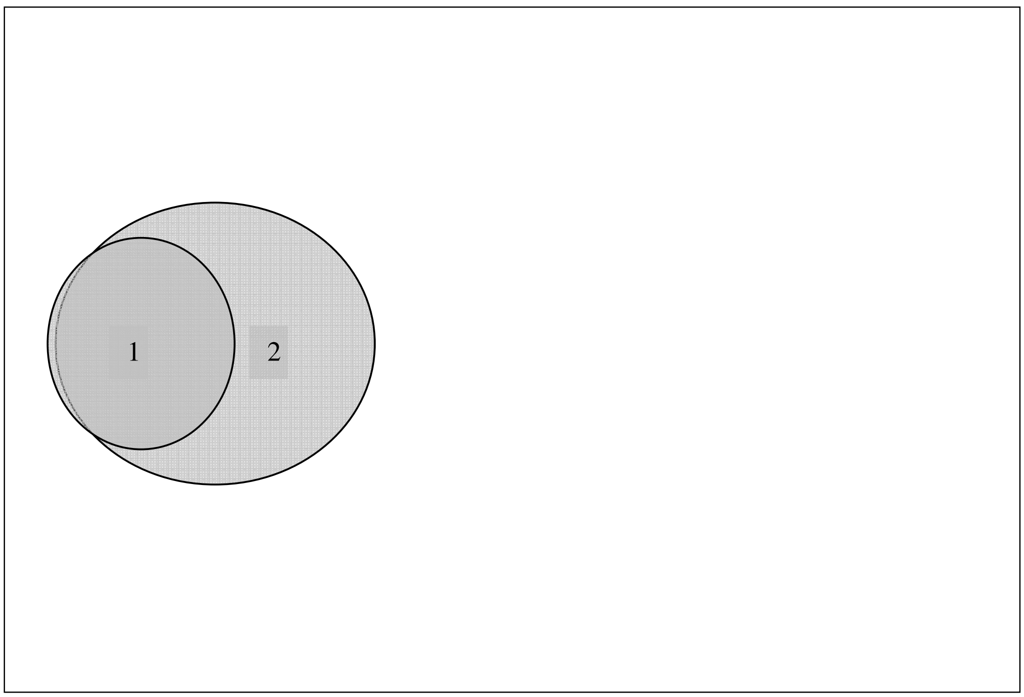


Initial analyses of interview data proceeded in two parts.

The first part involved a process of familiarisation that commenced with the recordings being transcribed. Duplicates of both audio-tapes and transcripts were made and stored in an independent location. Following the methods of Costin (2000) and Willmett (2002) and the recommendation of Ashworth and Lucas (2000), this was followed by: repeatedly listening to the recordings; reading and re-reading the transcripts, sometimes in concert with listening to the recordings; making notations on the transcripts related to sections of the dialogue that appeared initially relevant and significant. To enable links to be explored within and between transcripts, a system of identifying interviews was developed and implemented. This is detailed in Chapter Four.

The second part of familiarisation for analysing interview data involved the tentative identification of participant's "understandings, beliefs and awarenesses" (Costin 2000, p. 160). These were transcribed to individual cards, on which the participant's name and location within the transcript were recorded. The words spoken by the participant were likely be recorded in one, uniform, colour. Comments by the researcher were also added to link the participant's words to the "images" that appeared about participant's understandings (p. 160); these were recorded in a second, uniform, colour.

Stage 2*. Comparing, contrasting and grouping*



Following Stage 1, the individual 'meaning units' were sought from within the data. These were delineated by identifying those statements that offered a somewhat representative version of the entire dialogue; also known as condensation (Dahlgren and Fallsberg). This process of bracketing arose through the application of four questions:

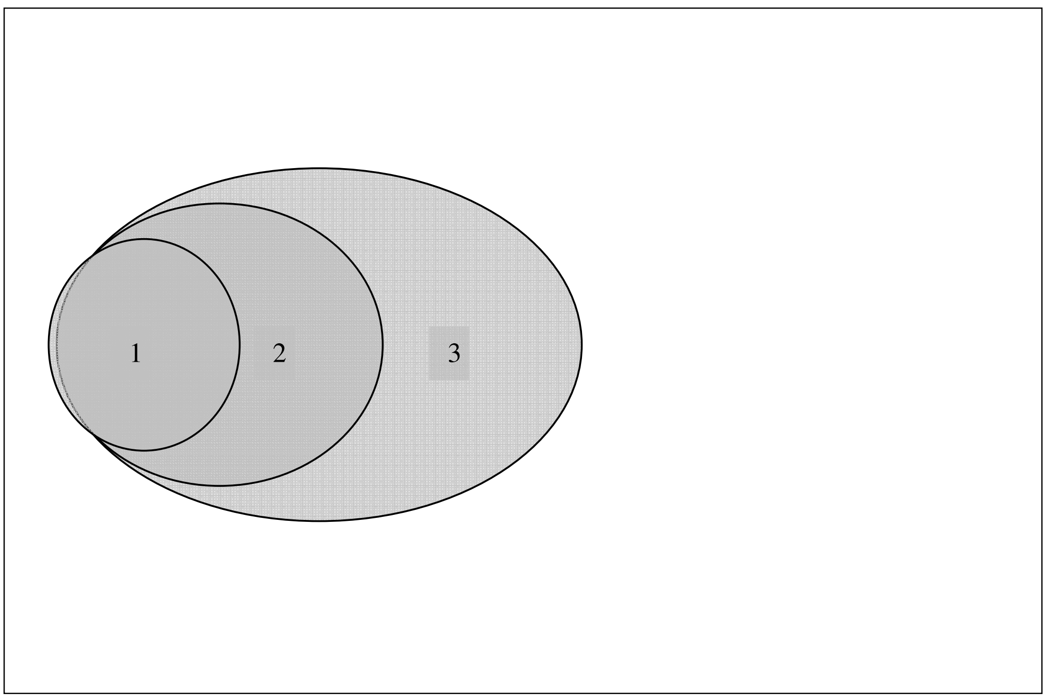
> What are the participants really saying here?
> What issue is being floated here?

What meaning units are becoming evident?

What ideas are appearing as common? (Herschell, 1997; Willmett, 2002)

By focusing on the variation or agreement that occurred within the data, the analysis moved toward a separation of the participants' individual statements and toward the formation of data that could enable the emergence of conceptions about GIS. Statements were continuously grouped and sorted to reveal meaning units which were connected and those which were isolated; also known as comparison and grouping (Dahlgren and Fallsberg, 1991). The major themes within the data were thus revealed, allowing for the tentative establishment of categories of description.

Stage 3*. Articulating and labelling tentative categories of description*



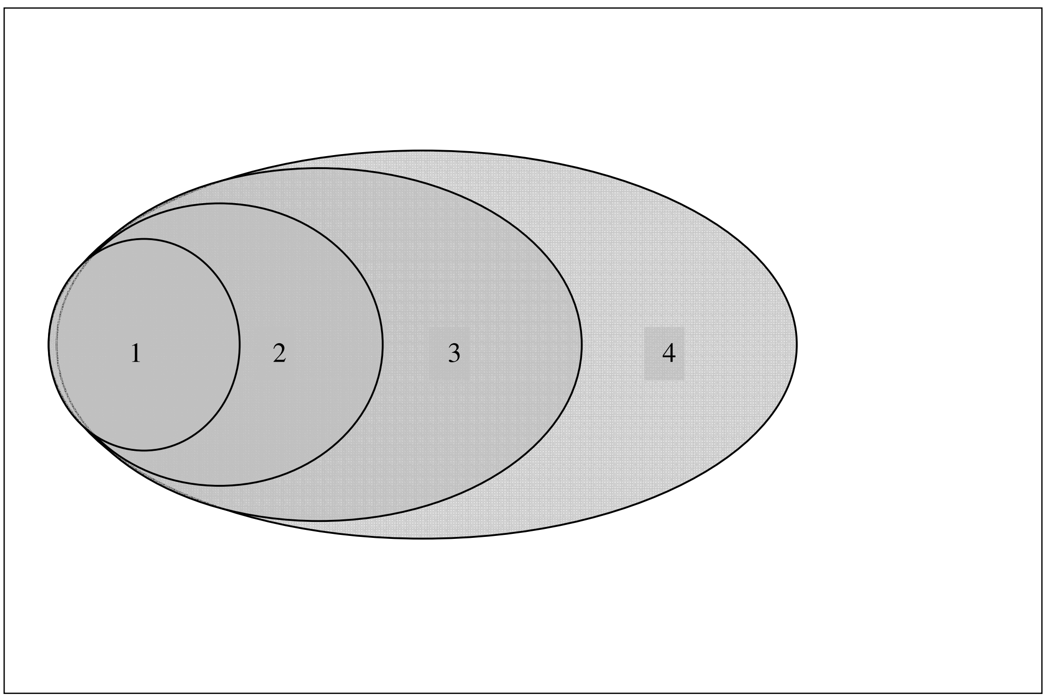
The process of identifying similarities and differences in Stage Two was extended into Stage Three. The groups identified in Stage Two were further delineated through the application of seven questions:

1. What is the nature of student understandings of the phenomenon of GIS, and what are the links between these understandings?

2. Are the understandings that have been identified facets of the same variant?
3. Are the understandings different?
4. How well does the verbal descriptor express each understanding?
5. Does the context of the understanding need to be revisited?
6. Is the researcher's bias surfacing?
7. How can the category be described accurately? (Willmett, 2002)

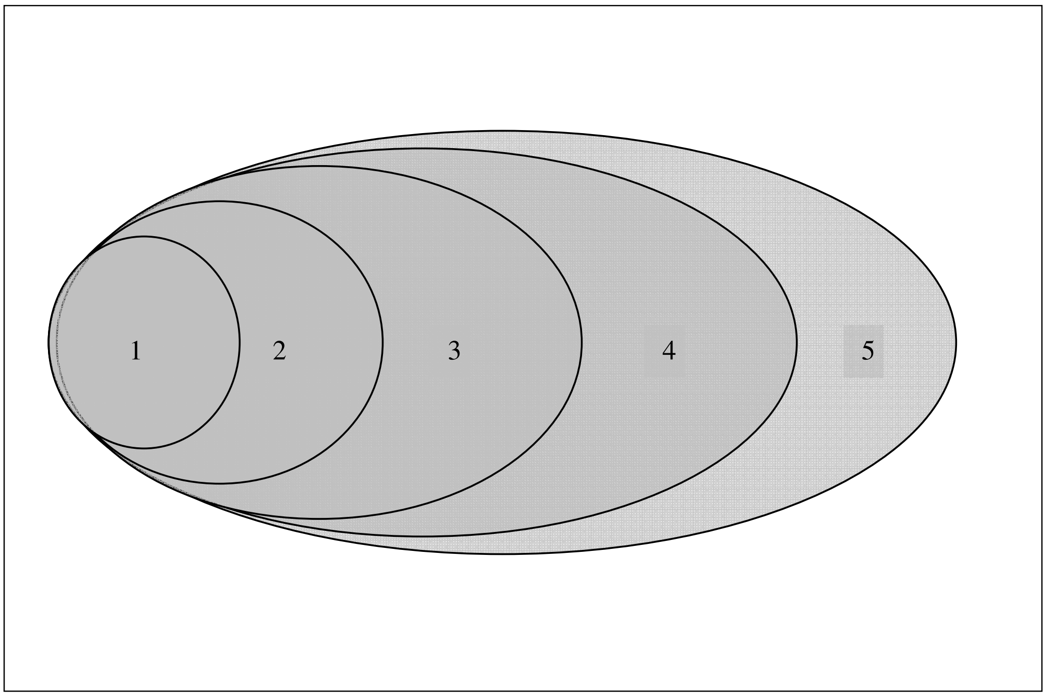
Categories of description were delineated in two ways. First, by allocating a term or phrase that appropriately reflected the focus of each meaning unit; also known as articulating (Dahlgren and Fallsberg, 1991). Second, by collating all statements related to each category.

Stage 4. ***Declaring the conceptions***



The process of Stage Four emphasised analyses within the categories that were delineated in Stage Three. The intention was to name each category, which Sandberg (1997) describes as the intentional constitution of the conception. Specifically, following Willmett (2002) and Costin (2000), each category was evaluated to: establish the focus of its variant; determine if it has a sense of wholeness, integrity and logic; and, discover an appropriate image from the data to illustrate its central focus. Declaration of the conceptions was through the construction of a suitable linguistic expression to denote the various categories; also known as labelling (Dahlgren and Fallsberg, 1991).

Stage 5. ***Constructing the outcome space***



The final stage in the analyses of data was the construction of an outcome space. This involved the arrangement of the qualitatively different conceptions in such a way as to communicate the different ways that the participants understand and conceptualise GIS. Generation of the outcome space occurred as a continuous and recursive component of the data analyses; a cyclical rather than linear progression, culminating in a diagrammatic representation of patterns that exist within and between the conceptions.

Categories of description, conceptions and the outcome space are described, defined and justified in Chapters Five. The implications of these findings are considered, limitations discussed and recommendations for future actions made in Chapters Six and Seven.

Trustworthiness of Research Outcomes

Within qualitative research, trustworthiness and reliability are drawn from the "dependability that the results make sense and are agreed on by all concerned" (Burns, 2000, p. 475). The trustworthiness of the research outcomes depends on a number of issues being addressed within the planning, implementation and analysis stages. Specifically, this section will describe how this research has included consideration of ways to ensure trustworthiness of both data collection and analysis.

A cursory review of published literature will reveal a broad range of design elements within phenomenographic research. The number of participants, their representativeness, interview design, participant age, group size, site selection, recording method, transcription method and coding method, among other, all appear to be quite variable (see, for example, Ahberg-Bengtsson and Ottoson, 1995; Bruce, 1994a; Dahlin and Regme, 1995; Dall Alba, 1994; Gerber, 1992b; Gerber and Kwan, 1995). Despite the variations, and as with other methodologies, phenomenographic research does present some limitations. Awareness of these served to pre-empt and mitigate any undue influence on the trustworthiness of the research outcomes.

Participants were drawn from four schools. By inviting all students enrolled in Senior Geography at these schools, the research presented the opportunity to collect the lived experiences of 109 students. As with other interpretive approaches to research, its goal is not to identify universal laws, but is to "understand particular actions and meanings in particular" (Smith, 1987, p. 176). For this reason, Pinnock's (2003) concern that the broad diversity within samples utilised in phenomenographic research can adversely affect the findings of research is moot. Notwithstanding this, by "looking at the specific .., [qualitative inquirers seek to] … understand it in particular and to understand something of the world in general" (Glesne, 1999, p. 153). Hence, by studying the conceptions of GIS held by this particular group of 109 students, and within a specific context – Senior Geography - it enables conceptual generalisations rather than statistical generalisations to be made by identifying the range of conceptions that exist amongst the participants.

Willmett (2002) and Willmett and Lidstone (2003) outline a number of disadvantages related to the use of synergetic focus groups within phenomenographic research. They note that a skilled interviewer is needed, and for three reasons. First, the interviewer needs to create a comfortable physical environment and emotional environment for participants. Second, the interviewer needs to craft the introductory monologue skilfully to focus participants on the discussion. Third, the interviewer needs to manage the interview preparation process such that the need for participant incentives is obviated and so that participants will ultimately "feel comfortable to share their perceptions with others". A further potential limitation relates to ensuring that enough groups are formed to "balance the idiosyncrasies of individual sessions" (Krueger, 1994, p. 36) although Willmett and Lidstone state that in their experience this is rarely a problem.

Credibility of the findings can be assured in a number of ways. Hence, the above limitations were mitigated through several design elements. With respect to the first limitation, since the participants were school students, their physical comfort during the research process was assured through use of those school facilities (rooms, furniture) with which they were already familiar. Similarly, the participants were familiar with each other and had considerable experience in working with each other; the emotional comfort of the participants during the research was thus expected at least to equal that of their usual school routine.

For the current research, the groups were those that pre-existed within the entire population being sampled. This serves to preclude Leinhardt, Stainton and Bausmith's (1998) concerns about conflict among group members and self-withdrawal from participation. Following the advice of Willmett and Lidstone (2003) and where practicable given the particular constraints of the sampling environments, the size of each synergetic focus group was planned to be between six and eight students. Groups of about this size provide more opportunities for individuals to speak and group support may more quickly develop. Having said this, in the event, groups ranged from four to fifteen students; this variation in group size reflected the unique circumstances of each cohort of each school, such as, but not limited to class size, timetabling and time constraints, and attendance. Arranging groups of this size range enabled several groups to be interviewed within each geographical context and exploited extant groups from within the total sample population. [Characteristics of each synergetic focus group are provided later in this chapter.]

The capacity of individual researchers fully to explore the data collected through phenomenographic methods has been questioned (Bowden, 1994; Marton, 1983; Säljö, 1994; Sandberg, 1995). Indeed, the trustworthiness of the interpretations made will depend upon the awareness of the researcher of his own biases and subjectivity. Sandberg (1995, p. 156) recommends that "interpretive awareness" be maintained through the process of data analysis to establish reliability of phenomenographic results. Following the recommendation of Glesne (1999), this researcher mitigated this by continually asking questions such as: Whom do I not see? Whom have I seen less often? Where do I not go? Where have I gone less often? With whom do I have special relationships, and in what light would they interpret phenomena? What data collecting means have I not used that could provide additional insight?

Within phenomenographic research, Breen (1999) observes the possibility for participants to talk about an area of knowledge in such a way that it seems as though they hold a well-developed conception of the subject, whereas in reality they may not. Similarly, Marton (1983, p. 289) argues that we should "distinguish between categories of description and that which is being described". Moreover, Säljö (1994, p.71) suggests that "the role of differences in conceptions of the world should be utilised much more restrictively".

In response to these issues, the process of planning, data collection and data analysis involved others. Specifically, the researcher's interpretations were checked against those of others with whom the threefold process of developing coding strategies, applying coding strategies, and interpreting coded data is shared. Likewise, the findings and interpretations of the researcher were checked against those of others, and in two ways. First, intersubjective agreement was achieved by the researcher and three others independently agreeing on both the allocation of statements to categories, and the categories themselves. Any disagreements were resolved by collaborative exploration of the statements and/or categories with respect to the total body of data, and attainment of consensus judgements. To further obviate any potential bias in the research process, two of the other critical friends at this stage of the analysis possessed limited knowledge or no teaching experience with either GIS or the Senior Geography syllabus.

The purpose of phenomenographic research is not to develop generalisations. It is, rather, to identify the conceptions held within a group of people within a particular context. The transferability of the outcomes of such an investigation are discernible through comparison of the context in which the research was undertaken with other, perhaps similar, contexts. For this reason, the processes by which data were collected and analysed have been clearly outlined. This follows Francis' (1993) recommendation for phenomenographic research procedures and their justification to be reported in full. For this research, the thesis includes rich description of several factors that influence the trustworthiness of the reported results: any limitations to the implementation of the intended method; any data source that was unavailable or partially unavailable; any particularities of the study site or participants that could influence the interpretation of data and wider application of its results (Glesne, 1999). In this respect, reliability of the conclusions is established through the explicit documentation of all steps and procedures that have been undertaken (Francis, 1993).

Ethical Considerations

Within research, ethical considerations relate both to the research subject matter, and the research method and procedures. The purpose of this section of the Chapter is to describe the ethical issues that were considered in tandem with the development and implementation of the current research.

According to Glesne (1999, p. 113), ethical "considerations are inseparable from your everyday interactions with research participants and with your data". Because the ethical dimension permeates all aspects of the research process, it was essential that ethical issues be considered at every stage of that process. This section will outline those ethical issues that are common to research before identifying specific considerations to ensure that the current research was undertaken ethically.

While different epistemologies may present particular ethical issues, there are a number of ethical issues common to research (Glesne, 1999).

The disparity of power within the researcher-participant relationship adds to the onus on researchers to protect the rights of the participants (Glesne, 1999; Williamson & Prosser, 2002). Furthermore, since the role of the researcher is not simply one of data gatherer, it is likely that the qualitative researcher is well placed to determine what constitutes ethical research. In this regard, any threat to the ethical integrity of the method was identified and mitigated during the course of this research. These threats and associated mitigants were drawn from reference to Burns (1997), Flick (2006), Kvale (1996), Merriam (1998), Murphy (2000), Orb, Eisenhauer and Wynaden (2001), Smith (1995) and Williamson and Prosser (2002). A summary of these is presented in Table 10.

Selecting the Participants for the Study

The purpose of this section is to describe the characteristics of the participating schools and students. This information is presented to enable others to make judgements about the extent to which the findings of the present investigation may be transferred to other contexts by way of conceptual generalisation.

This description is presented in two stages. First, the specific characteristics of each participating school will be introduced. These will include details of: its location, demographic composition and curriculum; the place of GIS within its curriculum; teacher expertise in the use of GIS and their attitudes and perceived impediments to its use in the school; and, the technical and other support for the use of GIS.

Table 10.
Mitigation of ethical issues common to research.

Issue	Description
Voluntary participation	Participants were invited to participate or otherwise prior to my arrival on-site, and then reminded by myself of the voluntary nature of any involvement (Appendix G, H).
Involuntary participation	Observation was limited to visible observations of participating students only.
Informed consent	Participant consent followed adherence to university and Education Queensland and/or individual school's guidelines for ethical research (Appendix A, B).
Deception	Participants were fully advised of the intended outcomes of the research and my personal and professional interest in it. Intended use of collected data and subsequent findings was made clear (Appendix F, G).
Role-Playing	Role play was not utilised.
Debriefing	Participants were informed of the nature of the research to reaffirm their trust in its motives. This included restating the purpose of the research, how it may assist future Senior Geography students, and an invitation for participants to both review and receive results (Appendix F, G).
Privacy and Confidentiality	Participants were clearly advised in writing and in person of the nature of how data will be collected and subsequently stored and used. Data coding methods assure the anonymity of participants (Appendix F, G).
Right to discontinue	Options for withdrawal following commencement of interviews were clearly outlined prior to commencement and, where considered appropriate, re-stated during interviews. Students selecting these options were no longer included in the research (Appendix G).
Experimenter obligations	All arrangements made with participating schools were upheld and processes were followed as stipulated in ethical approval documentation (QUT and Education Queensland) (Appendix A, B, C, D, E).
Publication of findings	Participants and participating schools and their staff were advised of the intention to publish and otherwise share the results of this research, thus reaffirming my intentions (Appendix C, D, E, F).
Stress	Participants were accommodated in rooms with which they were already familiar. Procedures for conducting the interviews were clearly explained prior to commencement. My interactions were at all times cordial and friendly (Appendix G).

Second, the specific characteristics of the participants from each school will be introduced. These will include details of: the number of participants from each year level; the proportion of OP-eligible and OP-ineligible students; the proportion of male and female students; the number of participants in each interview; conditions surrounding the interviews; and, if needed, any teacher comments about any aspect of their students' participation.

This information was collected to contextualise the investigation, and was obtained through informal conversations held with staff involved in the teaching of Senior Geography at each school.

The Schools and Their Characteristics

School A

School A is a co-educational government school that caters for 1450 students from grades 8 – 12 in a regional Queensland city.

All students in grades 8, 9 and 10 study the key learning area of Studies of Society & Environment, to which is allocated five 40 minute lessons each week. Students in grades 9 and 10 also have the option of studying Geography as a discrete subject, to which is allocated an additional four 40 minute lessons each week. Topics are studied in line with the route of inquiry and assessment instruments and assessment criteria reflect those from the Senior Geography syllabus.

GIS is a compulsory part of School A's Grade 8-10 SOSE and Grade 9-12 Geography curricula. SOSE is compulsory for all students. The way in which GIS are utilised within Senior Geography at School A is outlined in Table 11.

Of the 509 grade 11 and 12 students, 20 (7.1%) and 14 (6.2%) study Senior Geography, respectively. Five 40 minute lessons are allocated per week to each senior subject, with at least two of these being combined to form an 80 minute lesson.

Teachers of Senior Geography are all trained specifically to teach Geography. Additionally, in-house training is provided for staff in the integration of GIS within the school's Geography and SOSE curricula. To further assist teachers, highly prescriptive, step-by-step, instruction sheets are provided to scaffold the mandated GIS tasks. Beyond the compulsory elements, some teachers avail themselves of the opportunity to exceed the minimum requirements in line with their own levels of interest and/or expertise. However, this must not involve duplication of any aspect of the curriculum of any other subject.

The teachers involved in teaching with GIS appear to be cognisant of advantages and disadvantages for students in doing so. The advantages include: relevance from using an industry level software package; relevance from being able to undertake more tasks that more fully meld student lives and the syllabus; improved spatial/visual literacy; greater enjoyment of geography studies; real-world tasks. Beyond the students, the publicity that GIS' use in the curriculum had created was seen as beneficial for the school. Perceived disadvantages include: the time it takes to learn how to use it; the time it takes to teach how to use it; and, the differing capabilities and interests of staff were likely to influence how different students used GIS. Whereas some were limited to the compulsory items, others were exposed to additional studies involving GIS. An impediment to the broader use of GIS was seen to be the school's stated emphasis on teacher-centred learning, because this limits the scope for GIS' flexible use in classroom learning, e.g., individual and/or group-based tasks rather than whole-class tasks.

School A uses *ArcView 3.2*. While they also possess version 9.0, this is not used widely due to the belief that the data sets used with 3.2 are incompatible with this later version. The software is installed on individual computers. Data are filed on the network, but are accessible to students as read-only files. As needed, students save projects to their own network folders.

The computer resources needed to teach with GIS are also used for other subjects. Access is, therefore, competitive. To improve the likelihood of being allocated the time needed for GIS to be used, the tasks involving GIS are linked directly to assessment items. At School A, priority allocation of computer resources is directed to assessment related purposes.

Table 11.
The location of GIS within School A Senior Geography curricula.

	Theme	Topic	Main GIS Activity	Length	Assessable
11	Managing the Natural Environment	Responding to Natural Hazards (Core)	Mapping flood impacts in New Orleans; flooding & landslides in local area	6 weeks	Yes
		Managing the Coastal Environment (Elective)	Mapping study area based on fieldwork	6 weeks	Yes
	People & Development	Contrasting Development (Core)	Mapping indicators of development	6 weeks	Yes
12	Social Environments	Sustaining Urban and Rural Communities (Core)	Producing choropleth maps to support decision making exercises	6 weeks	Yes
		Investigating Current Planning Issues in Local Area (Elective)	Evaluating land use in different urban areas	6 weeks	Yes

Technical support for the use of GIS is strong, with the primary proponent for GIS' curricular inclusion possessing responsibility for the school's ICT program and resourcing. While School A possesses no specific strategic intent to encourage GIS use, it does provide whatever support is required to enable it.

School B

School B is a co-educational systemic school that caters for 775 students from grades P – 12 in a regional Queensland city.

All students in grades 8, 9 and 10 study Geography for one semester of each year (History is studied for the other semester). Two classes of each are scheduled to run concurrently. Each of the Grade 8 classes is allocated four 40 minute lessons each week. Grades 9 & 10 are allocated five 40 minute lessons each week.

Geography topics are studied in line with the route of inquiry and assessment instruments and assessment criteria reflect those from the Senior Geography syllabus. GIS are not mandated within the school's work programs for either Junior Geography or Senior Geography. However, the Head of Department (HOD) indicated that GIS would ideally be used for between 30-50% of allocated time in Grades 8-10. The reality is that the amount of GIS taught in these grades depends mostly upon the choices made by the teachers allocated. Since all Senior Geography classes were taught by a single teacher, who is comparatively skilled in the use of GIS, this issue does not extend into Grades 11 and 12.

The place of GIS within Senior Geography at School B is outlined in Table 12.

Of the 155 senior students at School B, 38 (47.5%) are enrolled in Grade 11 Senior Geography and 11 (14.6%) are enrolled in Grade 12. There are two Grade 11 classes, scheduled at different times, and a single Grade 12 class. Five 40 minute lessons are allocated per week to each senior subject, with at least two of these being combined to form an 80 minute lesson.

Senior Geography is taught by the HOD, who oversees History, Geography and SOSE curricula. All teachers of geography are trained to do so. Additionally, the HOD provides in-house training for staff in the integration of GIS within the school's Geography curricula. To assist teachers further, the HOD also provides to geography teachers highly prescriptive, self-paced work sheets for all classes, including Senior Geography. The HOD intends that this would redueing the need for teacher training. To further assist students, these work sheets are available to students and staff via the school's intranet; however, while the HOD and geography teachers intend that students access these while at home, they are not yet able to access the GIS software needed to undertake the activities.

As with School A, the teachers involved in teaching with GIS at School B appear to be cognisant of advantages and disadvantages for students of doing so. The advantages include: relevance from being able to undertake more “real-world” tasks; unlimited task options; improved cartographic mapping quality; and, opportunities to see vocational applications of geographical study. Perceived disadvantages include: the time it takes to implement stand-alone GIS activities; and, increasing difficulty in accessing up to data sets since a commercial market emerged several years ago.

The quality of available professional development was seen as limiting the quality of GIS’ inclusion within School B’s curriculum. Specifically, teachers indicated a desire to be taught how to do the things that they see at seminars and a frustration that so much of the available professional development was about what you *can* do with GIS, rather than *how to do* those things. According to the interviewed teacher, professional development to date has not been specifically developed to support Queensland’s Senior Geography. The final difficulty mentioned was insufficient time to articulate into classroom practice the ideas and skills that they learned during professional development training.

While School B teachers had considered collaboration to ease the perceived burdens of using GIS effectively, this was seen as something that was “difficult”. A similar attitude was held regarding the potential for GIS to integrate studies across traditionally discrete subject areas.

School B uses *ArcView 9.0*. The software is installed on individual computers. Data are filed on the network, and are freely accessible to students. As needed, students save projects to their own network folders.

The computer hardware resources needed to teach with GIS are also used for other subjects. While access is, therefore, competitive, teachers indicated that they “rarely” failed to gain the access that they required for GIS activities. GIS tasks are usually undertaken by using computer facilities for 2 lessons each week for a period of 4 weeks. Resourcing is such that the student/computer ratio is seen by teachers as “good”. Additionally, GIS are used as a teaching aid within classroom lessons, for the display of choropleth and orthophotographic maps in association with an interactive whiteboard.

The use of GIS at School B was not constrained by technical issues. Perhaps more significantly, administrative support was very high, with two senior members of staff being established and highly credible geography teachers with an enthusiasm to see GIS implemented successfully. Costs were seen as presenting no barrier.

Table 12.
The location of GIS within School B Senior Geography curricula.

	Theme	***Topic***	***Main GIS Activity***	***Length***	***Assessable***
11	Managing the Natural Environment	Managing the Coastal Environment (Elective)	Determining appropriate place for beach erosion mitigation structures	6 weeks	Yes
12	Social Environments	Local Planning Issues (Elective)	Producing choropleth maps to support decision making exercises	6 weeks	Yes

School C

School C is a co-educational government school that caters for 1353 students from grades 8 – 12 in suburban Brisbane.

All students in grade 8 study a combination of SOSE and Geography for one semester, and a combination of SOSE and History for the other semester. For Grades 9 and 10, students elect to study SOSE/Geography, SOSE/History or SOSE. Grade 8 and Grade 9 classes are allocated two 70 minutes lesson per week. Grade 10-12 classes are allocated three 70 minute lessons each week.

Geography topics are studied in line with the route of inquiry and assessment instruments and assessment criteria reflect those from the Senior Geography syllabus. GIS is not mandated within the school's work programs for Junior Geography and Senior Geography. Interestingly, the Head of Department reported that the nature and extent of GIS use in the school was a reflection of the ability and willingness of individual teachers to do so, and to do so in such a way that they in no way diluted or modified the stipulated programs of study.

Senior Geography classes were taught by two teachers, both of whom are trained geography teachers. One of them is highly skilled in the application of GIS to educational contexts, whereas the other possesses relatively few such skills.

At the time of collecting data, School C had used GIS as an element of a single Theme, Social Environments. These GIS-related activities occupied about five hours of class time, and were taught solely by the teacher with greatest skill and experience in its application to educational contexts. The GIS activities contributed to a single, assessable, task.

Of the 501 senior students at School C, 45 (16.8%) are enrolled in Grade 11 Senior Geography and 35 (15.0%) are enrolled in Grade 12. There are two classes in each grade, scheduled at different time.

School C offers no training in the use of GIS, and views its use as a "trial". Support for its implementation is minimal. Access to necessary computer resources is "occasionally" problematic, with the majority of GIS related activities being constructed to support tasks within the usual classroom by using the teacher's personal notebook computer.

The teachers involved in teaching with GIS at School C cited the same advantages, disadvantages and impediments as those from School A and School B.

School C uses *ArcView 9.0*. The software is installed on individual computers. Data are filed on the network and are freely accessible to students. As needed, students save projects to their own network folders.

The use of GIS at School C was frequently constrained by technical issues. The usual two or three week wait for technical support has resulted in the teacher reducing the complexity of what the class does with GIS so that any technical issues can be accommodated.

School D

School D is a co-educational government school that caters for 500 students from grades 8 – 12 in a metropolitan Queensland city.

All students in grades 8 and 9 study a total of three semesters of Studies of Society & Environment, to which are allocated three 70 minute lessons each week. Students in grade 10 elect to study one of History, Geography or Civics Education, to which are allocated three 70 minute lessons each week. Topics of geographical investigation within SOSE and in grade 10 Geography are studied in line with the route of inquiry and assessment instruments and assessment criteria reflect those from the Senior Geography syllabus.

GIS is not required for SOSE, but it is prescribed within the school's work programs for Grade 10 Geography and Senior Geography, requiring one of the three 70 minute lessons each week that are allocated to each year of the Senior Geography course. The way in which GIS are utilised within these Senior Geography curricula at School D is outlined in Table 13.

Of the 200 grade 11 and 12 students, 16 (16%) and 18 (18%) study Senior Geography, respectively. Three 70 minute lessons are allocated per week to each senior subject.

Teachers of Senior Geography are all trained to teach Geography. No formal GIS training has been undertaken by these teachers. Instead, they are largely self-taught, with occasional attendance at workshops hosted by teacher associations and/or industry. In line with this, the extent of GIS use greatly depends on the enthusiasm and commitment of individual teachers.

Table 13.

The location of GIS within School D Senior Geography curricula.

	Theme	Topic	Main GIS Activity	Length	Assessable
11	Managing the Natural Environment	Responding to Natural Hazards Murray Darling River (Elective)	Mapping & analysing relationships causing hazards	10 x 70min lessons	No
		Managing Catchments	Collecting primary data related to field study	8 x 70min lessons	Yes
	Social Environments	Human Movements (Elective) Sustaining Urban & Rural Communities	Mapping Our World	10 x 70min lessons	No
		Planning Places	Collecting & collating data related to field study	6 x 70 min lessons	Yes
12	Resources & Environments	Living in Physical Systems	Mapping Our World	7 x 70 min lessons	Yes
	People & Development	Contrasting Development	Mapping Our World	6 x 70 min lessons	Yes
		Feeding the World's People	Mapping Our World	4 x 70 min lessons	No
		Local Planning Issues (Elective)	Producing choropleth maps to support decision making exercises	6 weeks	Yes

The teachers involved in teaching with GIS appear to be cognisant of advantages and disadvantages for students of doing so. The advantages include: enhanced relevance due to the professional nature of the software program, and increased motivation of students; the ease with which GIS applications may be married with the syllabus, whereby exercises can be easily created for students to use GIS to meet syllabus needs; the self-paced nature of GIS tasks for students, with particular benefits being afforded to students for whom English is not the first language. Perceived disadvantages include: the difficulties of managing students during teacher-directed portions of GIS tasks; and, the length of time required to attain a basic level of skill. Perceived impediments include: the time required to prepare GIS-based lessons; and, issues surrounding the compatibility of other data sources with the software.

School A uses *ArcView 3.2*. The software is installed on individual computers. Data are filed on the network, and are accessible through students' own accounts. As needed, students save projects to their own network folders. A feature of network security at School D (and a considerable source of frustration for both student and teacher) is the freeze of a student's account if it remains idle for 5 continuous minutes; a side effect of this is the loss of all *ArcView* projects on which the student whose account has been frozen was working.

School D supports, in general terms, the integration of ICT across all curriculum areas. In terms of GIS, this support has translated into external recognition and industry grants for the further implementation of GIS, allowing for the purchase of more recent versions of software, and peripheral hardware such as GPS to enable GIS to be embedded across all grades. While the computer resources needed to teach with GIS are also used for other subjects, access is generous, with time beyond the 70 minute lesson each week usually available if needed.

Technical support for the use of GIS is inconsistent, with initial implementation being somewhat plagued by difficulties with installation and data management. This required the teachers involved to educate technical staff in tandem with their students and themselves.

The Participants and their Characteristics
School A

Three interviews were held at School A. Of the 34 participants, 14 were from grade 12 and constituted one focus group (Interview 1). The remaining 20 grade 11 participants were interviewed in one group of 12 students (Interview 2), and one group of 8 students (Interview 3). The characteristics of these students are shown in Table 14.

The composition of the interview groups was based on a combination of timetabling and self-selection. All year 12 students who wished to participate were invited to do so during a scheduled geography lesson. The year 11 class were invited to select which of two sessions at which they would participate. Interviews were held in the students' usual geography classroom.

Table 14.

Characteristics of School A participants.

	OP-eligible			OP-ineligible			n
	Int. 1	*Int. 2*	*Int. 3*	*Int. 1*	*Int. 2*	*Int. 3*	
Male	6	7	6	0	1	0	20
Female	6	0	5	2	0	1	14
n		30			4		34

Teacher observation was that the groupings reflected social preferences from within the classes. Interview 1 comprised contributions from all but four students. By contrast, all students in Interview 2 and Interview 3 contributed to the discussion.

School B

Three interviews were held at School B. Of the 41 participants, 10 were from grade 12 and constituted one focus group (Interview 1). The remaining 31 grade 11 participants were interviewed in one group of 13 students (Interview 2), one group of 10 students (Interview 3) and one group of 8 students (Interview 4). The characteristics of these students are shown in Table 15.

The composition of the interview groups was based on a combination of timetabling and self-selection. All year 12 students who wished to participate were invited to do so during a scheduled geography lesson. Grade 11 students for Interview 2 participated during their usual geography lesson time. Interview 3 occurred during those students' usual geography lesson time. Interview 4 was also held during a scheduled geography lesson, although these participants were drawn from both this scheduled lesson, and those students from the other geography class who were unavailable to participate in Interview 2. Teacher observation was that the groupings reflected social preferences from within the classes. No other teachers were present during the interviews. Interviews were held in the students' usual geography classroom.

All students made some contribution to the discussions.

Table 15.
Characteristics of School B participants.

	OP-eligible				OP-ineligible				n
	Int. 1	*Int. 2*	*Int. 3*	*Int. 4*	*Int. 1*	*Int. 2*	*Int. 3*	*Int. 4*	
Male	1	4	4	2	1	2	0	0	14
Female	8	7	6	6	0	0	0	0	27
n	38				3				41

School C

One interview was conducted at School C. All participants were members of a single Grade 11 geography class (Interview 1). The characteristics of these students are shown in Table 16.

The interview occurred during a scheduled geography lesson, and in the students' usual room. The students' usual class teacher was present during the room, but did not participate. Contributions were made by 12 of the 15 participants.

Table 16.

Characteristics of School C participants.

	OP-eligible	OP-ineligible	n
Male	2	1	3
Female	11	1	12
n	13	2	15

School D

Three interviews were held at School D. Of the 19 participants, 7 were from grade 12 and constituted one focus group (Interview 1). The remaining 12 grade 11 participants were interviewed in one group of 8 students (Interview 2), and one group of 4 students (Interview 3). The characteristics of these students are shown in Table 17.

Table 17.

Characteristics of School D participants.

	OP-eligible			OP-ineligible			n
	Int. 1	*Int. 2*	*Int. 3*	*Int. 1*	*Int. 2*	*Int. 3*	
Male	2	3	2	0	1	0	8
Female	5	1	2	0	3	0	11
n		15			4		19

The interviews occurred during a scheduled geography lesson, and in a room familiar to the students; either in their usual classroom, or in the classroom attached to the school library. The interview of grade 12 students occurred during their final lesson of the year. Grade 11 students were interviewed immediately prior to submission of an assignment; non-participation of six of the 18 grade 11 students was due to their preference to use class time to complete that task. The students' usual class teacher was not present during the interviews, but did enter Interview 2 briefly. Contributions were made by all students.

Chapter Summary

This Chapter delineates the epistemological basis for adopting a phenomenographic approach to investigate the research question of this study and outlines the specific method that was adopted to investigate the central phenomenon of this study: student conceptions of GIS.

The chosen methodology was selected by evaluating a descending hierarchy of four epistemological decisions with respect to the specific research question. First, an idiographic approach was required to investigate students' individual experiences of GIS, rather than the nomothetic approach which would investigate students and/or GIS itself. Second, a qualitative approach enabled an exploration of the way in which students engage with GIS, rather than the quantitative attempt to somehow measure the experience. Third, a constructivist approach recognised that students' conceptions were based upon the knowledge of it that they created through engagement with it, rather than the subjectivist approach which would assume some imposition of the investigator's own experience of GIS. Fourth, whereas researching from a first order perspective would enable the investigation of GIS, investigating students' experiences of GIS required this investigation to proceed from a second order perspective.

The chosen method was selected by evaluating the phenomenographic approach with respect to the unique nature of the research question. First, it reviewed the central assumptions of phenomenographic inquiry and their relevance to the current study. Second, it outlined the use of synergetic focus groups as the basis for the collection of discursive data and the role of the interviewer in these interviews. Third, it described the purposive sampling method needed to ensure data collection was commensurate with the aims of the research. Fourth, it declared the manner by which data were analysed to find and declare student conceptions and their cogent outcome space. Mitigants to threats to both the trustworthiness and ethicality of this research were introduced.

Chapter Three concluded with a description of the salient aspects of GIS' placement within the curricula of the sample schools and the salient characteristics of the sample population of students. This information is presented to enable readers to make decisions about the extent to which the students' conceptions of GIS emerging from this range of schools may be transferred to other contexts. While the findings of this qualitative research are not intended to be generalisable, it is possible to consider that similar contexts to those studied may derive similar conceptions to those found here (Marton, 1981a).

Whereas Chapter Three has introduced the contexts in which participants have experienced GIS and the framework adopted to investigate them, Chapter Four will reveal the conceptions of GIS that are held by these students. The implications of these findings will then be discussed in Chapter Five.

CHAPTER FOUR

CONCEPTIONS OF GIS REVEALED

Life would be so much harder in geography if you don't have GIS (t8 p6).

Introduction

This investigation into student conceptions of GIS involves a phenomenographic study based on data collected from ten synergetic focus group interviews with 109 students studying Senior Geography at four Queensland schools. Analyses of these discursive data revealed the qualitatively different ways in which students experienced and understood GIS. While each student may have expressed his or her understanding of the phenomenon in differing ways, and while each focus group interview may have proceeded independently, commonality was evident from within the participants' experiences and understandings of the phenomenon, GIS.

Emerging from these commonalities were conceptions of GIS, within which is captured the students' collective experience with, and understanding of, GIS in the context of their study of Senior Geography. This chapter presents two forms of data. First, it describes the characteristics of six individual conceptions, using Categories of Description. Second, it describes the relationships between the conceptions, as they contribute to an Outcome Space.

The Categories of Description

P1: It's just a program like any other computer game
P2: Just <u>another</u> program!!
P1: Oh well, it doubles up as a winter beanie, [for] when you are feeling lonely [and] you need some statistics to keep you warm .. (t8 p2-3).

Chapter Three outlined the purpose of phenomenographic research in discerning the qualitatively different ways in which people may experience phenomena.

The different conceptions of GIS held by students in this study are characterised in categories of description which, following Irvine (2005), have been constructed "to thematise the complex of possible ways to experience [GIS] and to highlight the critical differences between the different conceptions" (p. 126).

The following section describes the salient elements of each category of description to explicate the essential features of each conception. Each category is described in turn, with each description encompassing three elements (Bruce, 1997; Boulton-Lewis, Marton, Lewis & Wilss, 2004): a label; discursive description; and illustrative quotations (Figure 11).

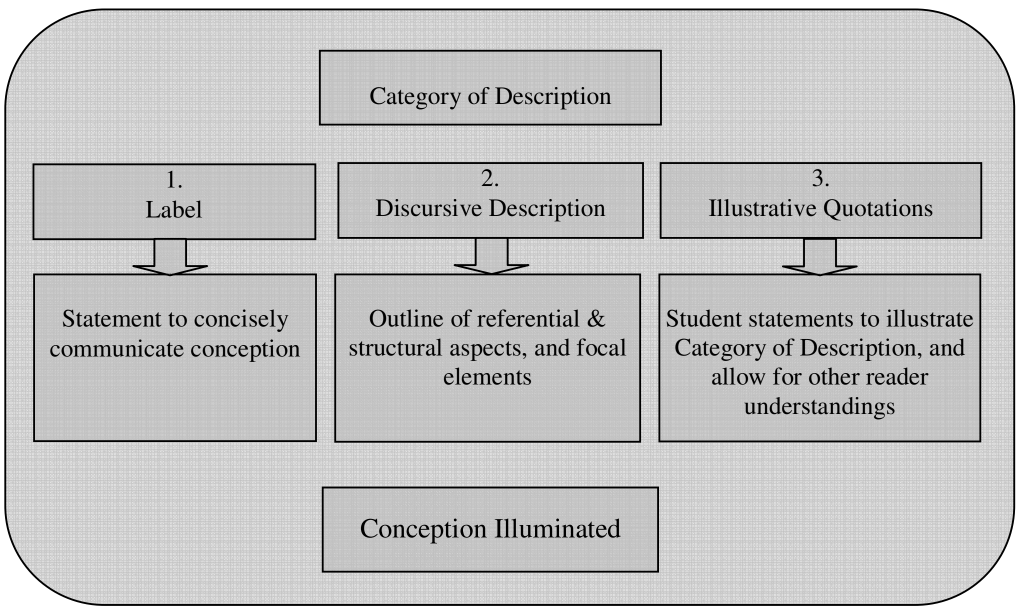


Figure 11. The three elements included in each Category of Description.

Additionally, each category of description includes a figure to illustrate the salient features of the conceptions that it captures. For clarity, each of these six figures adopts a generic format, as per Figure 12.

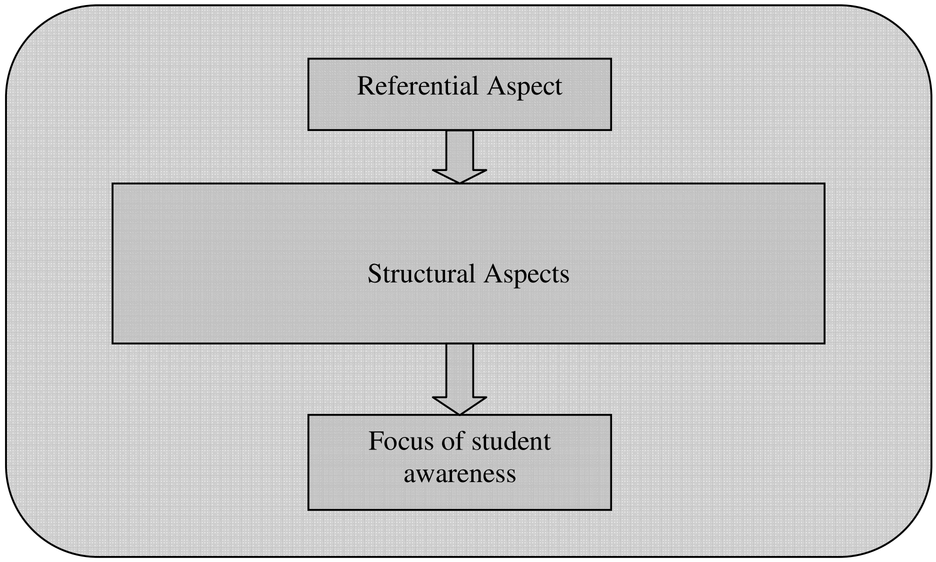


Figure 12. Salient elements of conception.

Where referenced, the transcripts have been coded to preserve the anonymity of participants and their schools. The coding uses, in order, the Transcript Number and Page Number. For example, *t2 p*3 identifies the excerpt as being from Transcript 2 and on transcript page number 3. Unless otherwise stated, each utterance is that of a single participant. Where the utterances of a number of participants are included to present an holistic view of a conversation, these are identified as 'P1', 'P2', etc. Similarly, interviewer utterances are preceded by 'I' and are presented in bold type. Additional information that is deemed necessary to improve clarity of the utterances is included in square brackets.

Category One: GIS As Maps And A Source Of Maps In Geography.

The first conception is of what GIS *are*. It is based on students' experiences of GIS as maps and a source of maps in Geography. Students experience GIS mostly as a product, wherein GIS is synonymous with the maps that students see while using it, regardless of where these may have come from, how they have been constructed and who may have constructed them. Perhaps unsurprisingly then, students recognise maps as a fundamental element of GIS.

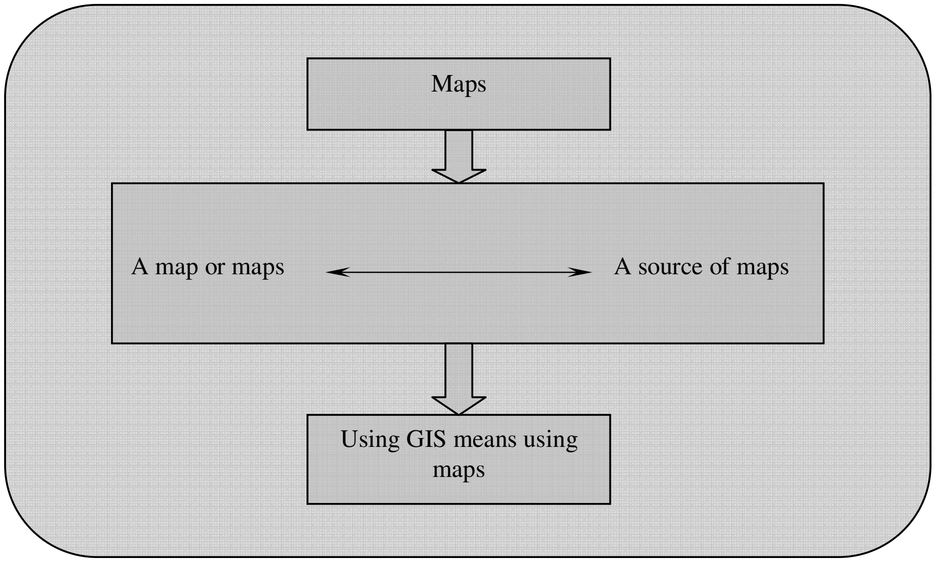


Figure 13. Salient elements of Conception One

Their experience of maps is twofold (Figure 13). First, they see GIS itself as a map, as evident in the following, representative, responses to the question, What is GIS?

I just look at it like a map (t10 p2).

It is an image that you have to view (t5 p1).

Second, and additionally, students see GIS as being a source of maps.

I: How would you describe it to someone who didn't know what it was?
A computer program that makes map ... it just makes map shells (t1p1).

In either situation, with students seeing GIS as both maps and as source of maps, the maps are in geography because the information that they provide is seen as equivalent to that otherwise obtainable from multiple sources of spatial information that students commonly use in class, such as atlases, text books and the apparently ubiquitous Internet.

I: What's in it?

Well, it has the [location] with all the streets and stuff in it. That was already there.
Like, everything's there (t5 p2).

GIS is just a program that you have on your computer and someone has put all this information from the Net, CIA World Fact Book, na na na na, it's like Bam! It's all on your computer (t8 p2).

Sometimes it's just a map where we can get, 'cause not often can we get a map of what we want, so we go to GIS. For [a particular location], we can just zoom in on one specific area, and that enables us to get the definitions (t3 p2).

As the last quotation suggests, students perceive GIS as offering not just a greater quantity of spatial data, but also a greater quality. Specifically, the level of detail about spatial phenomena is considered significantly greater in GIS maps than in other sources of this information that are used in their learning.

ArcView is like a lot higher quality of maps (t6 p2).

[It is] the only program I think that offers like a bird's eye view of the area and offers that much detail.
You can identify location and stuff. You know the sites and stuff that you are studying (t4 p1).

Something that is used to describe the certain location of [places] to help recognise things (t2 p2).

This belief extended to include the presumption that the maps are somehow built in to the software.

I: where do the maps come from that you use in GIS?
I don't know.
They're just on the computer and we find them (t6 p3).

It's there for you, but you have to ... you have to press the buttons (t5 p2).

Indeed, students display some difficulty with the conception that GIS could be anything other than the maps themselves, revealing some inaccuracies in their conceptual understanding of GIS. The extent of student misunderstanding of the source of data that GIS can and do store, manage and manipulate is widely evident. This is exemplified through the following interaction that occurred when, during one interview, the students' teacher unexpectedly entered the room during a protracted discussion about what GIS actually are.

P1: Where do they get the GIS information from?
[Teacher]: It's all free on the Net
P2: So they get all the info from the 'net, and you put it in to graphs for us?
[Teacher]: No, it gets put into a database.
P1: So, it already comes on the program (t8 p2).

Students clearly accept that data were a part of GIS, and that the maps in it were about those data. However, the notion that these maps are created as a result of the manipulation of data with GIS is, at best, tenuous. Indeed, the separation of data from the actual software remains almost as tenuous, as illustrated by the same students during a latter part of their conversation.

P3: Has the information been put there already, or does someone have to put it in?
P1: Obviously someone has put it in there for us
P2: No, it's obviously programmed in. it's obvious that there's no-one who's gonna put that much information in (t8 p3).

P2: ... are we talking about GIS or the data used by GIS?
P4: We already agreed that GIS was the data, that it couldn't be separated (t8 p7).

These difficulties are not isolated, as illustrated in the following group's conversation about the form in which data are saved in *ArcView*.

> ***I: someone mentioned something about ticking a box on the legend. What is that for?***
> *It activates it*
> ***I: so, if it is not ticked then it is inactive?***
> *Yeah*
> *Yeah*
> ***I: so, if something is inactivated, where is it?***
> *It doesn't show*
> *It doesn't show*
> *It's saved but it doesn't show*
> ***I: what is it saved as?***
> *It comes up like a skin on top of the map.*
> *It's saved under the map.*
> *In the display, it more or less doesn't exist (t10 p2).*

Category One – in summary

Students experience *GIS as maps and a source of maps in Geography*. As such, the referential aspect of this conception is maps. Structurally, this conception is experienced solely through GIS at once being maps, and being a source of maps. Focal in student awareness of their experiences of GIS is that their use necessitates the need to engage with maps.

Perhaps interestingly, all participants experienced this conception. As such, it is reasonable to consider it to be the experience from which all other experiences emerge or, as described by Marton *et al.* (1993), this conception is "prior and super-ordinate to the other conceptions" (p. 284).

Category Two: GIS As Mapping in Geography: A Way To Use And Create Maps.

The second conception is of what GIS are used for. It is based on student experience of GIS as an activity that involves maps in Geography. Whereas Conception One involves *GIS as maps and a source of maps in Geography*, Conception Two pertains to how these are employed in Geography. The qualitative difference then, is that Conception Two is about using maps, rather than simply experiencing those maps as a part of GIS. This conception is based on two aspects of student experience of GIS (Figure 14). The first is of GIS as manipulating mapped or mappable information. The second is of GIS as making maps.

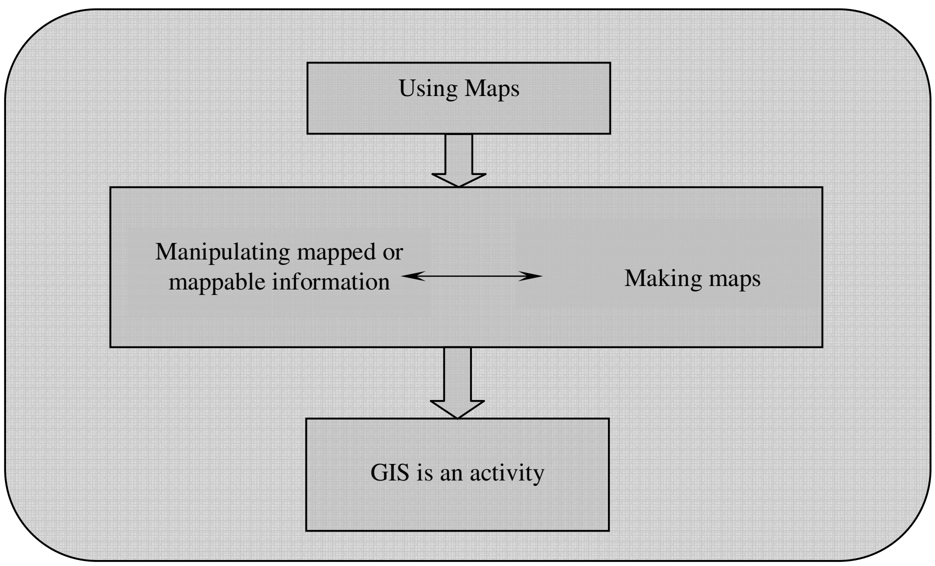


Figure 13. Salient elements of Conception Two.

> *I suppose it is a mapping tool (t2 p1).*

Students not only recognise that GIS have maps in them. They also recognise GIS as being a tool; that is, something that could be used for a purpose determined by the user, such as interrogating maps.

> *I think it is just used for mapping (t1 p1).*

> *It's primarily a geography mapping program (t3 p2).*

For students, GIS are synonymous with geographical activity, such as locating places, comparing magnitude, changing scale, classifying items and events, identifying patterns between such items and events, and seeking to make meaning of these activities. Such activities are widely referred to by students as 'mapping'. Since these mapping activities are undertaken within Senior Geography, students experience GIS as a phenomenon that is about mapping in Geography.

> *It's the only thing that we have available to use which will assist us in our efforts to locate where things are and measure and everything*
> ***I: So, what do you do with it?***
> *We make layouts of like certain points, the main aspects of something, like the buildings, the roads, the beach, the site we have created, and other things like that (t3 p2).*

The second aspect of students' experience of *GIS as a way to use and create maps in Geography* pertains to making maps. However, it is important to note that this experience does not extend to creating maps that display new configurations of either existing or added data. Rather, students are of the view that maps are made and stored as they appear, not that the maps are created through manipulating data that are referenced to points on the earth's surface. This view applies equally to maps based on extant data sets, as well as those that students have some role in creating. Indeed, when they are involved in creating maps, such as through the addition of data collected during field-studies, students believe that they are simply modifying something that already exists in map form, to (re)create something that would also, and subsequently, be saved in map form. And, whereas students use the term 'layer' quite frequently, this is usually in reference to those maps that are, as they believe, a part of the GIS program; any data input of their own serves the purpose of augmenting existing layers, rather than creating additional layers.

I: Let's go back a step. You went to the [field study location] and you collected the information. Where did you put that information?
We didn't put it anywhere. We got the picture off the computer and we added the information. We just put the lines straight on there. We didn't put it anywhere (t1 p4).

... we got the template of the area that we were doing, like the outline of the suburbs and then we copy a new layer and paste it up at the top, then we right-click it and find the information we wanted and then you click on that and we changed the breaks so we had the ones we wanted and then the colour we wanted, and then that went in and if we needed to we put the names of the suburbs on and then we do the layout and do the legend and the scale and…(t5 p4).

Because of these (mis)understandings, their conception of GIS as tools for mapping is limited to GIS providing a means for retrieving and altering maps. Perhaps surprisingly, and despite students seeing GIS first and foremost as a mapping device, they patently overlook its unifying, and unique, spatial dimension.

I: what other computer application is GIS similar too?
Movie Maker [from Microsoft]...you have things that you can apply to your picture. If you had a movie, you could get something on there, like a button, and it would apply it to your thing, like it does with GIS
it's kind of like the Internet crossed with a program because you can press a button and type in something and the information is there (t8 p4).

I: what other computer application is GIS similar too?
It's exactly like the Power Point one.
Or Microsoft Word (t9 p3).

Indeed, students grapple with the notion that creating a new map involves somehow changing pre-existing data. Instead, as illustrated in the following exchange, students recognise that GIS do manipulate the information that appears on maps, but fail to understand the data storage and handling procedures requisite to such alterations.

P1: I just look at it like a map, like a street directory kind of thing, and we're just colouring in its bits (t10 p2).

I: So, it's a map that hasn't been coloured in and you colour it in?

P1: Yeah, basically.

P2: You add data.

I: What does the colour mean that you add?

P2: Different things.

P1: Like residential and stuff.

I: So how do you go about adding those things?

P3: Oh, its confusing at first but then you get used to it.

P4: You can change the colours to whatever you want. But basically to differentiate between them, its just like using a key.

I: So the key links colours to something else?

P1: Yeah.

I: Where is that something else that the colours are linking to?

P2: The legend.

I: Where's that?

P2: You put it on when you finished.

P1: It's on the left hand side at the bottom.

P2: You make it, you enter the data.

I: Where do the data come from?

P3: The computer.

I: Where are the data?

P4: ArcView (t10 p2).

Category Two – In Summary

Students experience *GIS as a way to use and create maps*. As such, the referential aspect of this conception is using maps. Structurally, this conception is revealed through students' experiences of GIS: as manipulating mapped or mappable information; and, as making maps. Focal in student awareness of their experiences of GIS is that it is an activity. Evident from this conception is that students experience GIS as not simply maps (Category One), but the use of those maps.

Category Three: GIS As A Professional Mapping Tool: Exceeding The Needs Of Senior Geography.

Conception Three captures students' experiencing GIS as a product intended for a specific group of users: non-school users. It is based on four manifest aspects of student experience of GIS as being a professional tool (Figure 15). The first is of GIS as being beyond school need and IT capabilities. The second is of GIS as a being able to do many more things than they know it can do. The third is of GIS as doing the geography for them. The fourth is of GIS as a poor use of time.

The technical nature of GIS leads many students to question its relevance to school-level studies. Despite the potential for them to gain experiences that may not otherwise be available until tertiary or professional study, students are apprehensive about the value of software that, to them, is so clearly designed to do much more than they ever could. And, given the difficulties that students experience in using only a meagre few of GIS' capabilities, they seriously consider its intention for use in industry to reflect its inappropriateness, in its present form, for use in secondary school.

> *..like there are so many options..*
> *..a version for us that still does the same thing, like because we don't use absolutely everything on the other program. So, half the options sometimes might be easer to work our way around (t3 p2).*

The call by students for a 'watered down' version reflects their desire for a program that could just do two things. First, it would allow students to do just those tasks that they were required to do, especially those that were related to assessment. Second, it would allow students to do these within the relatively short time allocated during a school lesson, as compared with the more regular and extended use by industry persons for whom the program is actually intended.

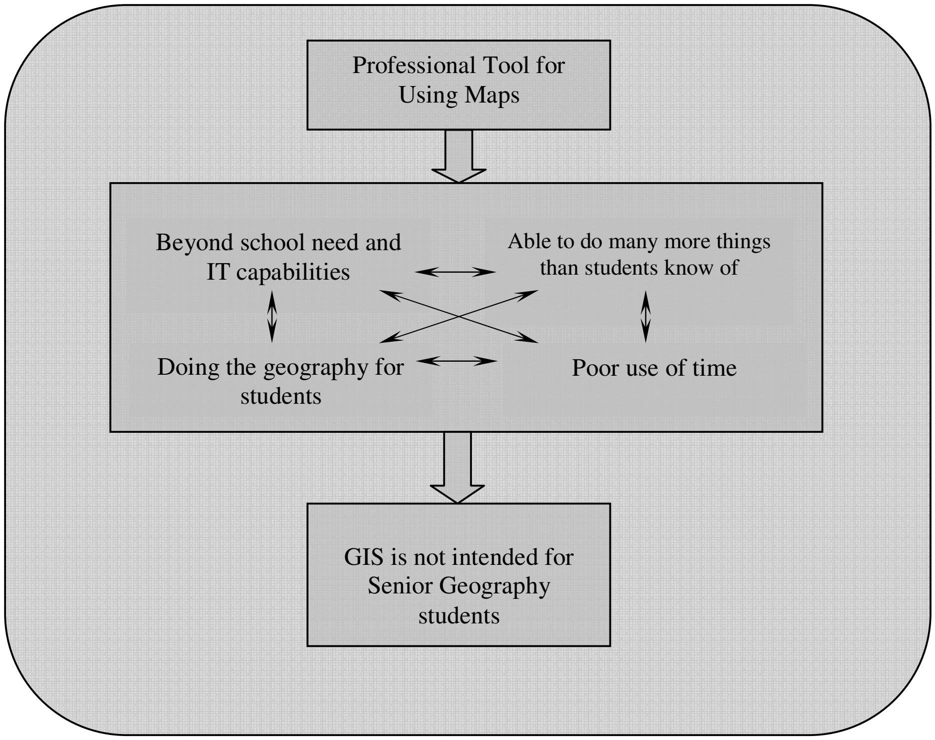


Figure 14. Salient elements of Conception Three.

This idea is preferred to the existing program that is, additionally, seen to tax already stretched school IT resources.

> *It's a big program to open up and because we're using it at the same time it goes slower (t6 p7).*

Advances in information communications technologies beyond the school gate are understood by students, including the likelihood that any software not specifically designed with students in mind will exceed the capabilities of the hardware/software provided in school and for school uses.

> *I would change the program so that it required less stress on the computers, so even crap computers could run it (t1 p4).*

As alluded to in some of the above comments, it is clear to students that the GIS software used by them is designed for applications other than in school geography.

> *P1: You can use it for something else.*
> *P2: There's got to be something else other drawing lines on a map (t7 p5).*

These potential applications are received with some excitement by students, who also recognise that being successful with GIS takes both time and persistence.

> ***I: earlier on in the conversation, you mentioned that there are functions that you haven't used.***
> *P1: Yeah, like there are 20 functions in the toolbox, and in each one of those there are 4 or 5 options, and we just use one.*
> *P2:Imagine how much you could do if we used all of them.*
> *P1: If we had more time as well to learn how to use all of them, I reckon it would be deadly.*
> *P3: If you just had time doing it by yourself, just mucking around by yourself, just figuring things out, you would be awesome (t6 p5).*

While this presents some value in terms of gaining experiences more clearly related to post-school opportunities, it also presents some difficulties, without which its use would be much easier.

> *It's gotta be a hundred different options in that toolbox and we've only used one and that was hard enough (t6 p1).*

This is a simple syllogism experienced by students. Specifically, students believe the GIS to be designed for industry. As such, it is capable of doing things required for industry tasks. Industry tasks are many more, varied and complex than those required by Senior Geography. Therefore, Senior Geography tasks using GIS become unnecessarily difficult since they are derived from using software that obviously has the capacity to do much more than students need to, and attempt to, do with it; and which has, as a result, many more ways to 'get it wrong'.

P1: We probably didn't use it to its full potential [in Year 11]
P2: It's like in year 12, we will probably use it a lot more.
P3: There's probably a lot more that we don't know about it, what it's good for.
I: Do you have any idea of what those things might be?
P2: Not really (t7 p1).

The difficulties students experience when using GIS are generally associated with the order of steps needed to complete a set task. Students see these complexities as unnecessarily great, leading to their experience that using GIS requires a great deal of thought. However, this thinking need not be so much about the geographical aspects of the tasks that they are meant to be doing with GIS, but about how to use GIS to complete those tasks.

But you're not using your brain.
You're just think[ing] about using the buttons (t6 p8).

Students are acutely aware of the difference in thinking when using GIS for a task and when undertaking the same task by hand. Specifically, they recognise that doing tasks with GIS requires, and nurtures, a lesser degree of cartographic skills and geographical knowledge than by completing the same task by hand.

No, but ArcView GIS puts into scale automatically and does all the calculations, but when we do it, we would have to go through and put it into scale and draw where the beaches are.
I think it makes us lazy.
You know, are we going to comprehend it more because we've drawn it, because I know the more times I do something, the more I remember it (t6 p8).

I: Let's say you did it by drawing instead of using GIS; what would you be thinking about if you were drawing it by hand?
If you got the measurements right.
If it was looking right, like what it was supposed to be doing.
If it was accurate and to scale.
I think that I think that there is an easier way to do it (t7 p3).

But, you see, when you're drawing you might actually be putting more attention into the actual map and the geographical side of it rather than ...'cause I know I didn't really think about it when I was drawing the breakwater or highlighting the erosion sites 'cause, I don't know, I wasn't really thinking about it and I would probably say that it was less when using GIS.
I reckon what [another student] said, like probably more when you are drawing it.
That's what I was saying before. When you draw it, you are thinking more about the accuracy ...
I found when I used the Arcmap I tend half the time to think am I doing the right thing, am I pressing the right button (t2 p3).

You're not actually thinking at the time (t1 pp2-3).

I agree that if it is tested, then as long as you remember the three steps then you are done; you don't have to have any real knowledge.
..it's pretty much just to not miss anything.
yeah, you don't have to do any work.
the only geography in it is collating data (t1 p1).

If you have the information there, like all the statistics and that, and you are putting it on to a map yourself [by hand], then I think you are learning more.
Yeah.
Cause otherwise [with GIS] you're just clicking it and it is just doing it for you.

And you don't actually have to take any notice of what is going on (t1 p2-3).

I: ..when you are constructing the same map using GIS, what are you thinking about?
When you're doing GIS, you're ...
You just think about clicking the right buttons (t8 p5).

Arising from this was students' experience of GIS as something that requires greater attention to its processes than the geographical purpose of those processes. An irony that emerged frequently from student discussions of their experiences was recognition that they are using GIS to learn about Geography, whereas GIS are designed for use by those who had already done so. Because of this, students' believe that their focus on the steps needed to complete a task often preclude them from actually achieving the task, let alone understanding its geographical significance.

When you think about it, you don't actually have to do any work. The computer does it all for you, you don't have to know anything (t4 p1-2).

Aligned with the earlier experiences of GIS as exceeding school need, being unnecessarily complex and demanding less geographical thought, students experience GIS as a problematic use of their class time. And, while they do see some merit in using GIS to complete class and assessment tasks, this is countered by what students see as the excessive amount of time required to complete them.

I: is using it the best way to use your class time?
No.
No, it's not.
I: Why not?
Well, you can draw maps yourself and since [GIS] takes too long you could spend more time on other stuff if you didn't have it; on writing …, like writing up reports if you didn't have GIS (t3 p2).

It's hard to understand. It's a waste of time (t10 p1).

This inefficient use of time is exacerbated by the view that the tasks themselves are not as immediately important or relevant to their studies as the tasks that they would otherwise be undertaking; neither are they as important for their progression toward attaining the learning objectives of Senior Geography. This is an issue compounded both by the time it takes to learn the appropriate software applications for given tasks, and by the time the software takes to process the steps involved in the tasks.

> *It takes ages for each thing to come up, like you have a little globe at the bottom spinning for about a minute then a picture will come up and then you will do one thing and then it will spin for about another minute (t6 p1-2).*

> *I don't know what I did for the 90 minutes but I did get the map finished but it's a long time for just one part of your assignment (t6 pp1-2).*

From the above discussion, it is clear that students experience GIS as either being poorly designed for use with school students, or being designed with a different audience in mind. Specifically, students believe that GIS are capable of doing much more than they know it can. When combined with their experience of GIS as demanding different thinking from that typically experienced in Senior Geography, students appreciate GIS as offering a worthwhile tool for professional use. As a professional tool, it is designed to be efficient and to be used by people who have a comprehensive understanding of its capabilities and their applications. As an educational tool, however, it is inefficient and used by people who have limited understanding of its capabilities and their applications. In this regard, GIS exceed the needs of the classroom.

> *It's professional (t4 p1).*

Category Three – in summary

Students experience *GIS as a Professional Mapping Tool: Exceeding the Needs of Senior Geography*. As such, the referential aspect of this conception is as a *professional tool for using maps*. Structurally, this conception is revealed through students' experiences of GIS as professional mapping tools through being: beyond school need and IT capabilities; as being able to do many more things than students know it can do; as "doing the geography" for students; and as a poor use of time. Focal in student awareness of their experiences of GIS is that their use is intended by an audience more geographically and computer literate than they are. Evident from this conception is that students experience a disconnection between what they see as the purpose of GIS and what they see as the purpose of Senior Geography.

Category Four: GIS as Frustrating Geography: Irksome And Presenting Many Challenges To The Student-User.

The fourth conception of GIS reveals students' emotive responses while using it. The term, "Frustrating Geography" is intentionally both noun and verb. Students experience GIS as *a* frustrating thing to do as part of their Senior Geography studies. Consequently, this leads to their experience of GIS *as* frustrating their progress toward what they see as the intended educational goals of Senior Geography.

It is based on four, interrelated, aspects of student experience of GIS (Figure 16). The first is of GIS as bothersome. The second is of GIS as tedious. The third is of GIS as difficult to learn. The fourth is of GIS as creating uncertainty.

> *P1: It's f**ked up.*
> *P2: I don't understand it.*
> *P3: I hate all computers and I hate that program (t10 p1).*

For students, using GIS are bothersome. This experience relates to GIS in terms of the complexity inherent within the software itself, the complexity of manipulating the software while being taught in its use, and the complexity of the tasks for which GIS have been employed.

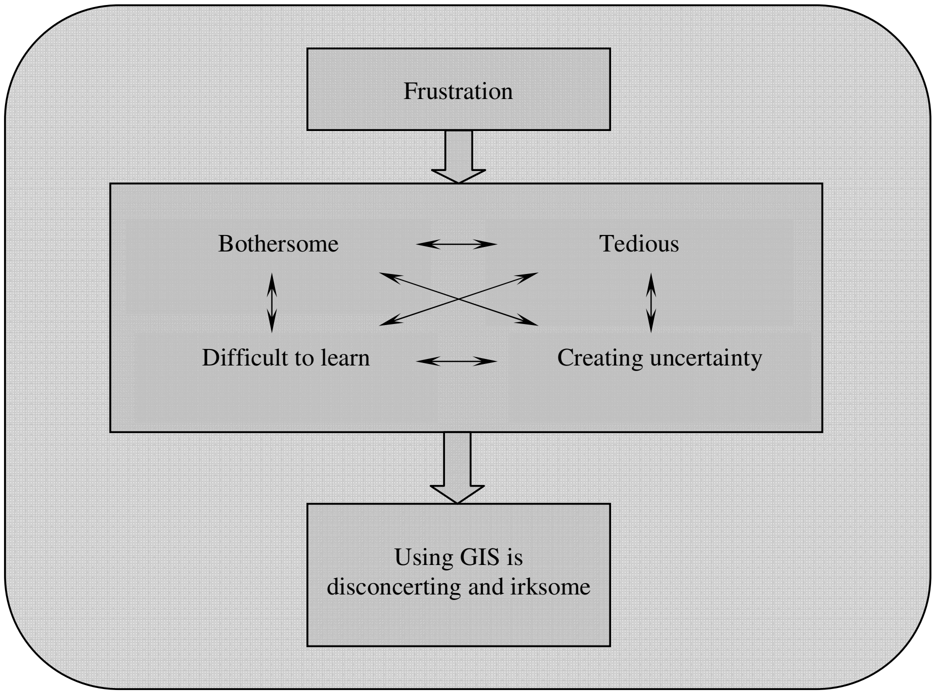


Figure 15. Salient elements of Conception Four.

As evident in the conceptions described above, students do not appreciate the way in which GIS store spatial data. This limits their understanding of how to manage the data that they are using. Specifically, they do not understand how attributes are stored to form themes, and that these are manipulated and displayed in layers to produce a map. Because of this, students have difficulty with using those GIS functions that are specifically related to doing those things; indeed, they have difficulty with using those functions that are fundamental to creating maps. Not understanding these functions while using GIS creates frustration for students.

> *I just kept losing my map; I did all this stuff on my map.*
> ***I: Where did it go?***
> *I don't know.*
> *[The teacher] brought it back for me.*
> *I just had to start again.*
> *Yeah, that just is awful (t1 p2).*

Students link much of their frustration while using GIS with the teaching that complements its use. Specifically, they view teaching of how to use GIS as compounding their difficulties in both understanding and using the software to complete the set tasks.

> *I don't even know what it is at all. I just do whatever [the teacher] says because I don't know what GIS is really meant to be or for, so I just do what [the teacher] says and I don't know why [the teacher] says it, and I don't worry about it because if I worry about it I just confuse myself (t6 p5).*

Students are aware that the time allocated to complete tasks with GIS is more limiting than that to complete other, non-GIS, tasks. This emerges from students recognising that teaching about and with GIS is more teacher-centred than other tasks; and necessarily so, such that students can gain an understanding, in the usually limited time, of how to use the GIS in the required way so that they may complete more successfully other, subsequent, tasks. Perhaps ironically, however, this mode of delivering instructions in either a verbal or pre-printed series of step-by-step instructions leads students also to view GIS as being a predetermined set of steps that must be followed to complete a task with a narrow focus, rather than a tool to increase both the range of tasks and the breadth of foci that they may encompass.

> *I remember using ArcView GIS and [the teacher] was telling us what to do and I got way behind and I didn't know what to do….so I got lost doing steps, and I got lost and by that time I was three steps behind and I didn't know what to do.*
> *[The teacher] goes too fast.*
> *And once you get too far behind, you just go, oh stuff it, I can't be bothered to do it (t6 p8).*

> ***I: How do you learn the correct order [of steps]?***
> *Someone tells you.*
> *You just keep fiddling with it until you get it right (t7 p3).*

> ***I: So, how do you learn how to use it?***
> *Repetition. You just go lesson after lesson on the same thing, learning how to do that thing until you can just do it (t5 p1).*

The third element of student experience of *GIS as frustrating geography* relates to the tasks that they are required to complete while using it. Students often see the tasks allocated to be undertaken using GIS as being unattainable. The apparent lack of confidence in using GIS functions, arising from the software itself and the means in which its use is taught to students (see above), appears to preclude students from recognising that GIS afford the potential to create multiple answers to any given question. Instead, they see the multiplicity of possible outcomes as undermining what little confidence they do possess. The whole experiential combination of complex software, inadequate instruction and difficult tasks appears overwhelming.

> ***I: What are you thinking about when you are using it?***
> *Oh God!*
> *It's hard!*
> *We're just thinking about how to, it's frustrating, and like how to operate it, how to get it to work, and like the why the person next yours looks different (t5 p3).*

Students experience difficulties in mastering a basic set of GIS functions, and they believe that repetition is the key to attaining mastery of them. Despite this, however, students' difficulties with using GIS appear to be further compounded by their experiences of it as generally repetitive and tedious and, for some, contrary to what geography is meant to involve.

> *[If] they introduced new things every week, like new things that you could do with it [GIS] then I might be interested for a long time, but if you just keep doing the same thing over and over then it could get a bit boring (t7 p4).*

Because in geography, you're supposed to draw, you're supposed to be outdoors, not stuck on a friggin' computer (t10 p4).

The unique nature of GIS as software that is used in school creates some difficulties for students, because they see the program as needing to be learned essentially from scratch.

I: who thinks it's hard?
In certain ways (t7 p3).

In this regard, they see GIS as being like other programs that they use widely in schools, but for which they have had much greater exposure; in some cases, extending into the lower primary years.

It's kind of like when you are five and you work Microsoft word; if you use it often enough you get to know how to work it (t7 p1).

As with learning how to use computers at an early age, students view GIS as presenting similar difficulties as learning computer programs and applications, but at an early age. The need to be taught everything creates a reliance on the teacher for direction, and creates difficulties for students who experience considerable alienation when exposed to this new program. Frustration is exacerbated by students' concurrent expectation that they should be using GIS to complete to a higher standard the tasks that they would otherwise have been doing in class without the computer and with a greater degree of autonomy.

I don't think it's very good because when you start using it the teacher has to explain it to everyone and no-one actually understands it.
Yeah, it was a bit hard to understand the first time we tried to use it.
I only used it once.
So every lesson [the teacher] he has to reteach you how to use it (t7 p1).

Compounding this is the variation in levels of ICT competence held by different students. Since an entire class is so often beholden to the teacher for direction, individuals who do grasp the steps earlier than others are largely hamstrung by the need to wait for those individuals who experience greater difficulty to receive the assistance they needed to 'keep up'.

> *I think it's hard. I guess, I think that when we were learning to do it, it was hard to follow. Well, I guess it's because I'm dumb on the computer, and we were all in there together and I needed individual help.*
> *I can back that up (t5 p1).*

However, as with other computer applications, once they perceive a reasonable level of control over the software, students are keen to explore. And yet, such confidence is ultimately eroded by them then progressing beyond the teacher's script, and experiencing difficulty with staying on-task.

> *I feel it's really easy to get lost with it. If you miss one step and you keep on going you don't know where you are (t6 p1).*

Indeed, students recognise that the time spent in waiting for the teacher to address the concerns of individual students in a whole-class lesson is commonly divided among those students who have difficulty in keeping up, and those students who have difficulty in restraining the urge to go further.

> ***I: you say you don't know what you did; how did you get it done?***
> *I don't know. It took me ages. If you were to put in Feature and then you press the button but if you weren't pressing the right one you lost it all so you have to do it again.*
> *And again.*
> *And you have to do it again like a million times.*
> *I lost mine like 5 times.*
> *And you need someone in the machine to tell you what to do; just some little Einstein in the corner of the screen to tell you what to do like "okay, next step…".*

> *There should be a manual for it.*
> *Yeah, we need instructions for it.*
> *You know how you get those books and stuff.*
> *Yeah, like "GIS for Dummies".*
> *Last year when we did FrontPage, [the teacher] made us a little manual with each step and that was really good.*
> *And we can use something like that.*
> *Then you could work at your own pace.*
> *But then you get frustrated because you don't know what to do.*
> *Like when you get a blue line around your Feature Class and you don't know what to do.*
> *You can try everything to get rid of it, but in the end we just started again.*
> *I think the reason why we lose so much stuff is because it stores your classes in a different place from that actual file you save yourself.*
> *And you can't make two with the same name; you have to come up with something different.*
> *You cannot press undo because then it will take off whole layers of what you have just put on (t6 p2).*

While students recognise that GIS are difficult to learn, they acknowledge that to do so is not beyond them. They are willing to learn how to use it, as long as sufficient time is allowed for them to do so.

> *The program to use? At first it's rather hard, but once you get the hang of it, it gets simpler. I still have trouble with it but you can work your way around it (t2 p1).*

Herein lies an irony. Students desire more time to explore with GIS, but to do so they require some fundamental competence in its use. While students see exploring individually as highly valuable in gaining an understanding both of the software and the data that are in it, they first require confidence in using its more rudimentary functions; a few of the many buttons about which they often lament.

It’s confusing with all the buttons, like [we] have to get to know the software or whatever it’s called (t7 p1).

It’s a lot more complicated.
Cause, yeah, it’s a lot more complicated … because you like have to have experience to create map in ArcView GIS (t5 p2).

And yet, to gain this experience they need individual assistance. But this is not forthcoming until such time as most students possess the basic skills to be able to explore and use the software with some degree of confidence.

I guess that it not the GIS system itself but it is the learning process.
And, which affected the number of people using it.
I think like if we all had individual help then we all would have used it, but like, no offense to the teacher – [they are] self-explanatory, very well – but when you had a friend go over it with you it registers, sunk in (t5 p1).

I: So, how do you get to be comfortable using it?
By doing the exercises.
Follow the instructions. The teacher usually gives us the instructions; how to start, and then start using it.
I: Can you describe a typical lesson where you are using it?
Yeah, [the teacher's] got a data projector.
It's showing up and like we have the instructions on paper.
[The teacher] goes through it with us.
[The teacher] will show us pretty much how to do everything.
[The teacher] will go step by step through everything.
[The teacher] demonstrate the exercise.
If you fall behind, it sucks.
I: Why?
Because, if [the teacher is] say three exercises in front of us, then each of us will probably be asking the next person for help and then that person will fall behind.

So it's really important for [teacher] to make sure that all students are on the same page.

I: So how do you make sure everyone is on the same page?

[The teacher] makes sure that we are following it.

No, not really. [The teacher] finishes the task and then [the teacher] walks around.

And tells us what to do.

Yeah, like telling us not to swear about the program.

I: How do you know whether you have completed [an exercise] correctly or not?

You don't.

'Cause [the teacher has] got a demo for us.

It has pictures on the paper to show what is on the screen.

I: So, if it already has been done and it is on your page, and your just following the teacher's steps, step-by-step-by-step, what is the point in doing it?

[The teacher] does that, [the teacher] goes through it with us and all that, but that's just the first time.

We sort of know what to do because [the teacher] sort of already taught us from the start and the next exercise we know how to do it – as much as we can by ourselves – and when we need help, we ask [the teacher].

[The teacher will] explain it again.

[The teacher will] do it the first time and then [the teacher will] do it a few more times so we get the gist of it. But, then we still have it on paper, so we know what were doing, but sometimes if you're having trouble, then you can ask for help. But, [the teacher] won't be doing step by step every time (t10 pp1-2).

A further paradox for students is that to learn how to use GIS effectively, they need to experience repetition.

I: So, how do you learn how to use it?

Get help from the teacher.

Repetition. You just go lesson after lesson on the same thing, learning how to do that thing until you can just do it (t5 p1).

However, the very repetition needed to master GIS appears to contribute to the tedium that students experience when doing so.

[If] they introduced new things every week, like new things that you could do with it then I might be interested for a long time, but if you just keep doing the same thing over and over then it could get a bit boring (t7 p4).

Furthermore, this repetition requires a teaching approach that emphasises a particular order of steps and which is, inevitably, directed by the teacher.

In any event, the collective tension experienced by a class attempting to focus on forward progress amid myriad hardware, software and learning distractions in a time-poor environment precludes an emphasis on how GIS actually process those steps to manipulate the spatial data involved, and why such manipulation is required. As such, students seem to be stuck in a cycle that prevents them from understanding, from a spatial perspective, what they are doing; an understanding that students sensed could perhaps lead to greater self-reliance with its use.

I think the problem is it is so hard to explain to someone why we are doing this. Like, for example, if someone saw that you had a certain image in your Word document, it took me forever to explain it, so I ended up just saying do this, do this, do this, rather than saying you do this because.
Yeah.
We should be given examples, and we should be given reasons for it, the because I think we have sort of been pushed into it, pushed off the cliff … because he hasn't given us a manual for it, but I think that if we explore it for ourselves then, we know it's hard, but I think we'll get a better understanding of it in the end.
I don't even know what it is at all, I just do whatever he says because I don't know what GIS is really meant to be or for, so I just do what he

says and I don't know why he says it, and I don't worry about it because if I worry about it I just confuse myself.
This assessment piece, the criteria was to show a map that showed the breakwater, he didn't give us or say that you can make a map, or what sort of map, so we just did what we're told to do because that's what he wanted (t6 p5).

Arising from these issues is the repeated call for GIS to be more extensively and routinely used prior to entering Senior Geography, suggesting that earlier exposure may obviate many of the fundamental causes for the frustration experienced by participants.

I think it would have better if we learned how to do it earlier and not just in Grade 12 and how to do other things.
We were thrown in the deep end.
The year 9s are using it.
So if we had used it since Grade 8, we'd probably have a better idea of how to use it more efficiently (t1 p3).

Interestingly, however, if this were to lead to improved efficiencies in the use of GIS prior to Grade 11 then, presuming participants' attitudes toward GIS' role in learning are true retrospectively, we could expect that many would see GIS as a draw card for the study of Senior Geography. However, generally speaking, GIS are not a motivator for electing to study Senior Geography.

I: What are your thoughts about the extent to which GIS influences subject choice; do you think it does or doesn't at all?
Nope.
No.
It doesn't at all (t4 p2).

In this respect, students are acutely aware of the perceived expectation of their teachers that success in these tasks comes when students' complete the same task that the teacher had at some earlier time, and which the teacher was either personally repeating for students to replicate in the classroom, or which they had translated into step by step instructions for students to follow and, thus, replicate. Compounding this, students do not share the palpable enthusiasm for GIS that their teachers routinely display.

> ***I: Why do you think your teacher and your school has chosen to [use GIS]?***
>
> *Because [the teacher] is into that (t9 p4).*

Instead, students view their completion of GIS tasks as somehow satisfying their teachers' needs moreso than they themselves achieving satisfaction from their learning about and with GIS. Because of the above experiences, students harbour the notion that maybe the benefits of GIS for Senior Geography are somehow overstated. Students are more likely to express concerns over GIS' value in tandem with their expression of concerns about their own confidence when using it. This uncertainty appears to be due to a combination of poor skills in its use, ignorance of its applications beyond school and, significantly, scepticism about its reliability and accuracy. This scepticism is evident within the following excerpt from Transcript Six.

> *… it doesn't necessarily make it more correct, and this is against it, because we're presuming that the … if it's a photo, then it's going to be right. But, for all we know, this photo could have been taken five years ago.*
> *Yeah.*
> *That's the thing.*
> *I know that's negative, but you don't know. You see, those wave fronts could have been from five years ago and it could be completely different now.*
> *It's not accurate.*
> *That's the thing, because technology is…*

If we took our own pictures, like wave fronts and time taken and everything was controlled, then we would be getting accurate measurements in everything (t6 p5).

Control over what is happening while using GIS is seen largely as extrinsic. As suggested earlier, students believe that they are simply following a set of predetermined steps/functions to achieve an equally predetermined end. As a result of this belief, students are heavily focused on completing these steps in what they assume is a non-negotiable manner. The possibility that there may be a raft of options in addition to the prescribed steps does not seem to influence their approach to the GIS tasks.

…you're not going to know if the colours have gone into the right place
You could have got something mixed up and got the colours in the wrong spot, and how would you know?
Because, you don't like, because when we did the test, we don't actually know where it shows up. You can learn the Layout and know you are right with that, but when it comes to the actual map, you're not going to know if you're right.
We just assume that we are given the right information.
We just have to assume that the computer has put things in the right spot and that we have done that right (t1 pp2-3).

Despite the GIS tasks undertaken by these students generally following the route of inquiry and therefore representing, to some extent, an open-ended inquiry, they still seek confidence through comparing their own screens with those of other students and, more significantly, those of their teacher. Indeed, this lack of confidence leads students to reconsider whether to use GIS or to continue with the more traditional methods employed in class, as exemplified in the following comment by a student who consistently selected to do his/her maps by hand rather than risk getting it wrong using *ArcView*:

… that's why we chose to do the colouring in because we're more confident (t5 p1).

Because students are not overly familiar with the steps involved, they are not fully acquainted with the role of GIS in providing for them an opportunity to undertake a more independent investigation. Their preoccupation with which buttons to press - the method of doing GIS - in this way interferes with their use of GIS for the purpose intended by their teachers.

> *Another difficulty with GIS is that if you make a mistake, you have to pretty much redo everything.*
> *You can click "undo".*
> *Sure, but you don't know you've made a mistake until the teacher checks it at the end (t 13 p8).*

> ***I: What do you learn, what do you think about while you are doing the GIS stuff?***
> *How to press the buttons.*
> ***I: How do you know if you press the right button?***
> *You get taught it.*
> *It's like cause and effect; if you press the wrong one, then you can undo it if you don't like it and try a different button.*
> *Experiment.*
> ***I: And then how do you know you have got the right one?***
> *You get the result you want.*
> ***I: How do you know the result you want is correct?***
> *Because it looks the same as the one on the board (t7 p2).*

The possibility that there could be many 'correct' answers arising from the application of GIS' functions to a single set of data that is manipulated concurrently by many students adds to the uncertainty that any one answer is correct, rather than freeing students from the constraints imposed by the belief that there can be only a single, correct, outcome.

> ***I: How do you know if you have achieved the things that your teacher wanted you to?***

Because he tells us.

We get a tick.

Correct.

I: Would you know, without him actually saying, whether you got it right or not?

If he taught us how to do it in the first place, yes (t1 pp2-3).

Category Four – in summary

Students experience *GIS as Frustrating Geography: irksome and presenting many challenges to the student-user.* As such, the referential aspect of this conception is frustration. Structurally, this conception is revealed through students' experience of GIS: as bothersome; as tedious; as difficult to learn; and as creating uncertainty. Focal in student awareness of their experiences of GIS is that its use is disconcerting and irksome. Evident from this conception is that students experience GIS as both academically and personally discomfiting.

Category Five: GIS As Relevant Geography: Within And Beyond The School Experience.

The fifth conception of GIS is about students' perception of the connectedness between it and other aspects of their studies and lives. It is based on four aspects of student experience of GIS as being relevant: to different learning styles; for geography; for computer skills; and, to general life (Figure 17).

Students appreciate that GIS offered a different way to do things. Specifically, this relates to their experience of GIS as being both a new way to do old things, as well as being a way to do new things.

It's a different way of learning (t8 p4).

I: What are you learning while you are doing it?

Learning things. Like learning how to do something that you couldn't before.

Yeah, new things (t5 p3).

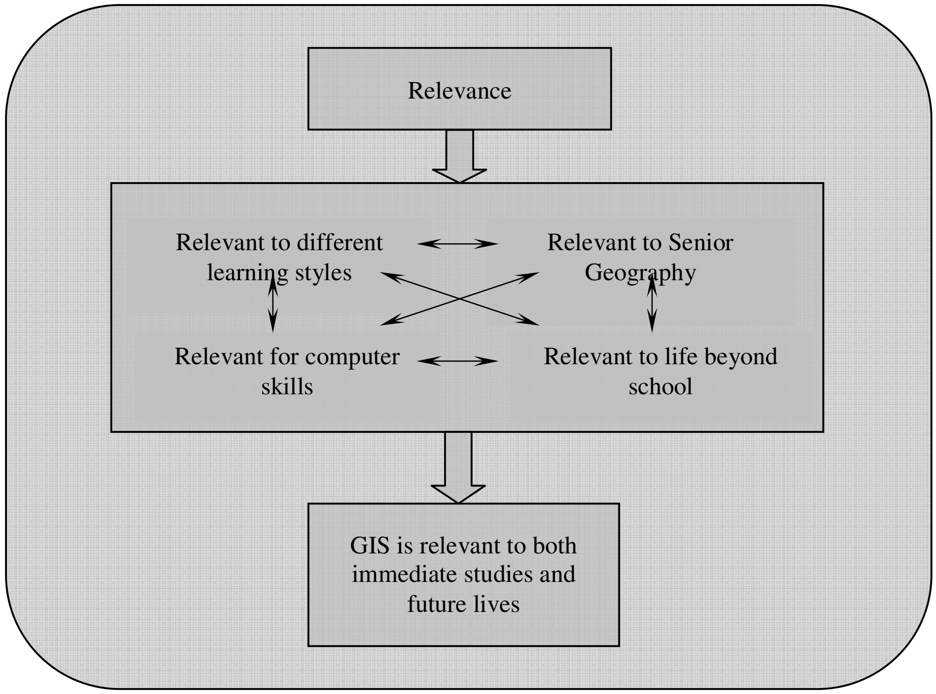


Figure 16. Salient elements of Conception Five.

For many students, it is the former that constitutes one of GIS' greatest benefits, namely it allows students to learn in a way that is not otherwise available within their studies of Senior Geography.

> ***I: Do you think it is a good use of your time?***
> *Yeah.*
> *Yeah.*
> *Yeah.*
> *Yeah, it's better than writing all the time.*
> *Yeah, like people learn things like say people might learn things by writing things down, people might learn by hearing things, and some people are physical learners and like for the visual learners of the class could really excel by using the program (t2 p2).*

> *... and it's visual, too.*

Some of us appeal to colours (t8 p3).

This visual nature of GIS and its emphasis upon graphic presentation of data, regardless of the extent to which they correctly understand it, appeals to students. This is for two reasons. First, it adds variety to their lessons. Second, they find it more stimulating, and are more inclined to retain their motivation and concentration than were they to do the equivalent task using resources other than GIS.

When I'm drawing a map I'm grumbling, I'm whingeing, I'm pissed off, because I don't like tracing paper and lead pencils just give me the shits.
I think if you've got a book that has got all the bloody details in it that you just copy to make a map to put on a bloody clipboard, then I don't see the point. It is a lesson waster and a time filler.
That's why it's [GIS] more stimulating, being able to have something there immediately and go "yep, now I can look at this and see it" instead of going "oh my god, this is really crap" and then you go "why did I just do that?" (t8 p5).

Well, when using GIS I am thinking that this is interesting, but when I am doing it by hand I am thinking that this is boring (t8 p5).

A further reason for GIS' relevance to learning styles is its capacity to reveal the interconnectedness of things being studied. Indeed, it is this aspect of GIS, either directly expressed or otherwise, which is largely responsible for students' belief that it is relevant for geography; both as a discipline, and as the subject, Senior Geography. This capacity emerges through student use of several data manipulation functions, and specifically those related to zooming in on specific map features, and constructing the layers of maps to make more clear the relationships between such features and other features.

... and you can open up a map and a graph and look at the statistics.
You can analyse stuff.
And you can watch the difference in things (t8 p3).

ArcView has helped us with our report because it has shown us different times of the beach's profile. The [study site] has gotten smaller so we know that over time it has gotten smaller, it has shrunk and stuff. It has helped us (t3 p1).

Because it caters for a wider range of student learning preferences, students experience GIS as improving their collective understanding of the topics being investigated. It also allows them to gain a greater understanding of those topics than would otherwise have been possible. As indicated in Category One, this is due to the wealth of data that GIS comprise, which allows students to determine to a greater extent the direction of their investigations.

It makes information more accessible.
...and from that you can convert it to your own needs, through the maps, through the tables and the graphs (t8 p1).
It has all the information you will need, it's got population density, rainfall.
I: All the information that you will need for what?
Well, for geography. It's about geography, all about the world (t8 p1).

This is not just because of the presentation, but because having a more accurate map when commencing the study of a new area, especially during fieldwork, allows them to develop a better understanding of the area being studied. In turn, this allows students to (potentially) undertake more accurate analyses and make what they believe to be better decisions.

An adjunct to this intrinsic motivator is the extrinsic motivation of GIS tasks being linked to assessment. In this regard, student interest in using GIS is largely shaped by the assessment related to it and, since students experience assessment as being relevant to Senior Geography, they also experience GIS as being relevant to Senior Geography.

I: How often would you like to use it?

On a regular basis.
Well, if I had one of those assignments every week then I would want to use it every week. I'd use it as often as I needed to do what I had to do (t7 p5).

I think it is a valuable resource for Senior Geography, because it helps us accomplish our assignments (t3 p1).

I: What benefit is there in having used it at school?
Um, because … you use it for assignments (t5 p2).

So you can be accurate in what you say and write about it.
So you can get a better mark (t5 p4).

Coincidentally, many assessment tasks referred to by participants involve fieldwork. The relevance of using GIS in local area studies is particularly evident for students, with their added understanding of their local environments improving the level of interest in, and hence, motivation for, what they were studying. The discovery of their own home, school or significant other landmark involves students in further immersion in GIS (although not necessarily in the prescribed task/s).

Using GIS I can actually see into my yard, and whatever's on the roof of my house I s'pose.
You can actually see the people walking to work (t3 p1).

The relevance of using GIS in field studies extends beyond the matters under study, to include the relevance of using ICT as part of those studies. Indeed, students see computer technologies as the way of the future, and something that is relevant for schools to engage.

... or like trying to modernise our school and get us using computers and stuff (t8 p4).

With this in mind, they see using computers at school as being both a means and an end. As a means, students experience GIS as helping them to learn how to use another software package, thereby giving them a broader base of computer skills.

> *You learn more about computers because everyone will need to know how to use computers after school; everyone will have to know how to use computers out of school (t1 p1).*

> *For instance, it is good to have computer skills (t1 p1).*

> *It's introducing us to technology as well (t1 p2).*

> *If we come across a program that's kind of similar to it then we will know, we'll try the way we did the GIS maps and see if that way of clicking the buttons will work (t5 p4).*

As an end, they see it as more appropriate in the contemporary technological environment to make a map with a computer than with pencils and paper.

> *The technology of maps today, like not everything needs to be hand drawn and that. We can just use the computer (t5 p3).*

> *Geographers will rely on computers in the future (t10 p5).*

Perhaps more pragmatically, students are keenly aware of competition for access to ICT resources at school. In this regard, the relevance of using GIS for computer skills is complemented by the experience of improved physical comfort offered in a computer room when compared with a usual classroom. The link between success in GIS activities and subsequent, additional, time in the 'computer room' is clear to students, with several students acknowledging that they intentionally experience GIS favourably simply because of the greater comfort offered by the room in which they use it. Indeed, a number of participants admitted to working harder in lessons involving GIS so as to increase the likelihood of further classes being held in a computer room.

> ***I: If you weren't using GIS, what would you be doing instead?***
> *We'd be sitting in the classroom and if it's a hot day then we'd be sweating, but if we do GIS then we get to go to the air-conditioning (t9 p2).*

> *P1: Primarily it's to get us into air-conditioning.*
> *P2: Once a week, in the air-con for 70 minutes is great.*
> *P1: Anything that gets us in there is good (t8 p4).*

Perhaps more seriously, the relevance of using GIS to post-school life is clearly identified by many students.

> ***I: Beyond school, why do you think your teachers use GIS as part of your Senior Geography?***
> *Because it is more of a life skill, like it's something that is practical, we can use it (t1 p2).*

Experiencing it at school is seen as a 'natural' extension, given the potential applications of it beyond school. Interestingly, it is experiencing GIS that leads to student awareness of these applications, which in turn creates the perception of its relevance. GIS' relevance beyond school is initially identified as being associated with further (post-school) study that also uses GIS.

> *Because if you do geography at uni or whatever you'll never actually have to sit down and colour something in, everything is done by computers now, so it is more useful (t1 p1).*

> *If you want to go to uni and study geography or cartography or something to do with geography then you will probably have to use it (t1 p4).*

If I'd never used it at school then I would never know what it was and you would never, I would never use it out of school, so it's good to have it at school (t5 p2).

And that's such a skill by itself, like learning all the buttons what to press will be also helpful with if you want to ... you know what I mean, like, learning the way to do it is valuable, it's not just...you are learning how to do it in the future (t3 p2).

For all groups, discussion about the possible place of GIS within and beyond the senior school curriculum invariably led to the possible vocational opportunities that may also arise from having used it.

We're also given an insight to what tool you can use not only at school and when we leave school what tools we can use in the workforce (t2 p2).

Students recognise the breadth of occupations that may in some way use or benefit from using GIS. This involves both identifying actual jobs that may require it, and identifying GIS as a skill that is transferable across many, traditional, jobs.

I s'pose If you want to become a cartographer, you don't draw any more so you may need it (t1 p1).

If you're in a construction job, or in town planning, you need to be able to look at an area and see what you can do with it and see what services and housing and stuff you can put there if you are in that industry (t2 p3).

It would be useful in the army.
I: How?
Navigation, logistics.
…yeah, logistics, finding the positions on a map
..tactics
..tactics, yep (t3 p2).

In short, students experience GIS as relevant, by virtue of it being a microprocessor technology at a time when such technologies exert influence on all areas of students' lives. In this respect, they see GIS as being commensurate with a range of academic, vocational and life situations, thus engendering their experience of GIS as being relevant.

> *Drawing a map is, like, olden days, but GIS is modern day technology.*
> *I guess it's a skill really (t8 p6).*

> *Like, if you are going into some big geography firm – I don't even think there are such things – so if you're in some big firm, I don't even think they are going to make you draw a map by hand.*
> *You need to do it faster.*
> *Exactly, that's what the real-world is; newer, faster stuff (t8 p6).*

> *People who analyse lots of information would need it, they couldn't not use it (t8 p7).*

> *And it's what they do in the real world anyway (t1 p4).*

Category Five – in summary

Students experienced *GIS as Relevant Geography: within and beyond the school experience*. As such, the referential aspect of this conception is relevance. Structurally, this conception is revealed through students experiencing GIS as: relevant to different learning styles; relevant to Senior Geography; relevant for computer skills; and, relevant to life beyond school. Focal in student awareness of their experiences of GIS is that its use is relevant to both their immediate studies of Senior Geography, and to their future lives. Because GIS, as part of the study of geography, offer relevant learning experiences and opportunities, its use enhances the relevance of Senior Geography to students.

Category Six: GIS as a Better Geography: Offering A Superior Curriculum, And Broader Geographical Education, When Contrasted To A Senior Geography That Omits Its Use.

The sixth conception of GIS is about GIS as providing better Geography. The term, "Better Geography", as with Category Two, is intentionally ambiguous. As a noun, it refers to GIS as being a superior form *of* Geography. As a verb, it relates to students' experiences of GIS as being a superior way to *do* Geographical activities. It is based on four aspects of students' experience of GIS, and emphasises the future benefits of using GIS (Figure 18). The first is of GIS as being worthwhile once you know how to use it. The second is of GIS as an efficient use of time. The third aspect is of GIS as a presentation tool. Finally, the fourth structural aspect is of GIS as a better way to do geography.

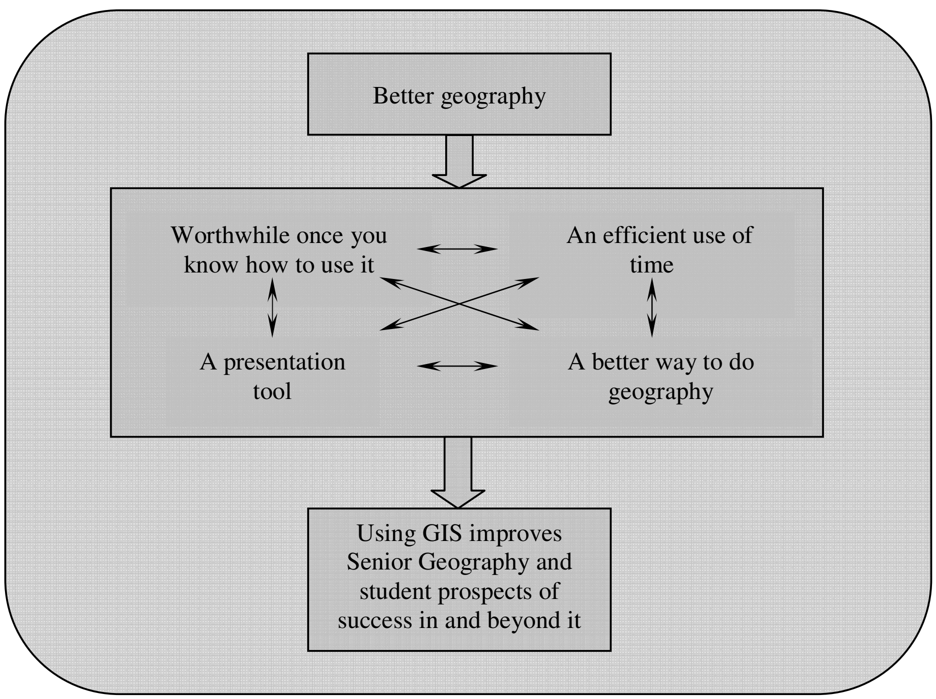


Figure 17. Salient elements of Conception Six.

Students experience GIS as something that is difficult to master, but something for which a base level of competency could be attained given persistence and discipline.

P1: I don't think it's stupid; I think it makes geography easier.

P2: Yeah I reckon.

P3: 'Cause geography is good, but it is a bit hard. ArcView helps us, it makes it easier. That's my opinion; I don't think it's stupid and it's not hard to understand.

P2: I reckon if you know how to use it, it's really good. But, if you don't, then it's very frustrating. Like, it took me a little while to get used to it and I hated it at first, but then once I knew how to use it, there's a whole range and variety of statistics and things like that that you can access. It's just that knowing how to access it (t10 p1).

Notwithstanding the issues associated with earlier conceptions, students see these difficulties as an acceptable price to pay for the benefits that they perceive as being provided from using GIS in Senior Geography. Even the most rudimentary level of ability, students believe, is sufficient to enable them to access these benefits. And, since they see repetition as the key to improving skill in its use, students recognise also the role of persevering with a task in improving the likelihood of not just completing that task, but in also enabling subsequent, and potentially more difficult, tasks to be completed.

P1: But once you know what you're doing, you're kind of, it's good.
P2: Once you know how to use it, it is easy to use (t1 p1).

But after I used it for a while I got used to it (t2 p2).

P1:...but if you take three hours to get used to it, then it's good forever after that. (t10 p3).

Once you get to know it a bit better it will be okay.
It could be easier; once you know how to use it.
I: What do you think would need to happen in order for you to know how to use it?
Use it more often.
Yeah.

> ***I: Do you think it is a good program to use at school?***
> *It would be once you understand what you are doing.*
> *Yeah.*
> *Yes.*
> *Yep (t5 p2).*

Once students experience learning how to use GIS as a worthwhile exercise, their attention moves to whether it is an effective use of their class time.

> ***I: What you do in one GIS lesson would take how long in "normal" classes"?***
> *Like, weeks.*
> *Hours.*
> *Yeah (t8 p4).*

Much debate occurred within every group about whether using GIS was an efficient use of time. Using it, some believe, gives them more time to do other things, such as work with the maps that they create.

> *Well, it doesn't actually take a lot to make a map. It only takes a few minutes, so that's probably a good thing.*
> ***I: Why is that a good thing?***
> *Because it doesn't take as long time to do it, you then just, you spend less time on the one project and then you have more time for other stuff (t5 p1).*

> *It makes it a whole lot easier and faster to gather information (t9 p4).*

For students, it also prevents the boredom that they associate with drawing maps by hand. This serves a twofold purpose; first, it eliminates the perception of time passing slowly. Second, it leads students to experience Senior Geography in an improved light.

Like, to start with we were given a sheet and we had to colour each section in for like, we had a country and each thing was like a different thing, and one colour is 45 to 50, and another colour was, and so on and so forth, but with GIS we can just do it in 5 minutes instead of sitting there colouring it in and drawing all the keys, so it is good in that way.

I: If you weren't using GIS, what do you think you would be doing instead?

Colouring in.

Doing it by hand.

Tracing a map.

Everything by hand.

It would take way ever.

And it would be really boring.

And it would be really messy (t1p1).

Further, GIS' efficiency is seen as being derived not from doing the usual classroom activities faster, but from being able to do more and other, better, activities in the time that would otherwise been allocated to undertake those usual activities.

With ArcView, we can decide whether we want a certain range of data to be shown or not, and then we can print off a total picture, as opposed to having a hand drawn one. It saves a lot of time (t10 p3).

I: What is the closest in-class activity to what you do with GIS?

You can't. It's just impossible. You'd have to get maps, you'd have to get charts, you'd have to get all this different information.

Either access the Internet or get books to research.

See, like one of these [referring to a student drawn map on the board], we could do 40 different maps.

See, that's all in GIS. You don't have to go through books and books and books, it's all there... (t8 p 4).

Students believe that overcoming GIS' difficulties will lead to improved efficiencies. Associated with this, students possess a broader view of the role of GIS within their education; at once serving the immediate needs of Senior Geography, and serving the needs of a broader, geographical education. In this sense, students experience a favourable cost/benefit ratio associated with GIS, regardless of what their preferred learning activities may have been.

> *I would rather draw a map myself if I need the information, but in class, if you're given a task and you need the information, then you need to do it as quick as practical, and get it accurate (t8 p6).*

> ***I: Last year you didn't use GIS, this year you did. In which year do you think you were exposed to better geography?***
>
> *P1: This year. There's no question. This year, we have gone through far more information.*
>
> *P2: Yeah.*
>
> *P3: It's more detailed, maybe it's because we're in Year 12, but it's just more useful stuff that we've analysed ...*
>
> *P1: We went through a lot more information and a lot more quickly than last year.*
>
> *P4: Yeah, applying climate and terrain to figure out what was going on in a country. We were able to do it a lot quicker, in a couple of lessons, rather than looking it up on the Internet, doing the map, figuring it out, doing that sort of thing...so, we got it done quicker, and be able to move on through more information (t8 p8).*

For most participants, a key part of this cost/benefit scenario is the better way to present their maps.

> *I think it's not just so much what we learned from it, but its about the presentation of the data that we pick up (t10 p3).*

GIS enable students to communicate more clearly than by using words alone. This reflects their experience of the cliché that 'a picture tells a thousand words', where the maps and layouts that they generate make it easier to communicate their ideas and findings.

> *It makes us, it's a better way to show what we want or what we are thinking about the task at hand instead of having to either draw or completely describe it in writing, you could show it on the picture in through GIS (t2 p1).*

> *P1: I like it, because it makes things very easier.*
> *P2: You can see things clearer (t10 p4).*

GIS allow students to create higher quality maps than were they to draw them by hand. In this way, as a map-making tool, GIS provide a range of functions that students will otherwise complete with an obviously lesser degree of accuracy, or would not complete at all.

> *On the map you could have a whole wad of; you can't fit as much data on an A4 piece of paper as you can in ArcView. In ArcView you can put a whole heap of information up there and hide it, so it's not always in your face. But with a map, you can only put the stuff that's going to fit on a page. Like in ArcView, you can put in details about site locations, and countries, cities, all kinds of stuff. Whereas a map alone is just an illustration, ArcView is a lot more than just a picture, a map (t10 p4).*

Such inaccuracies/omissions of constructing maps by hand can distort their geographical thinking, which students see as placing downward pressure on their results.

> *In a way, our maps are slower to draw. If you made a mistake by colouring in, then you have to live with it, or you have to go and get another one and start again, and then what you write about it will be wrong too.*

I think that one of the benefits of using GIS is that we [those students who chose to do their maps by hand instead of using GIS] had more chance of making mistakes (t5 p5).

For this reason, the value of GIS in improving presentation quality is closely linked to its role in deriving better assessment results for users than non-users.

It's probably the most time consuming thing we do, but it's probably the most valuable for assessment (t3 p2).

Students expressing this conception are aware that they are among the minority, statewide, of students using GIS as part of their Senior Geography. Within Queensland's system of school-based assessment and moderation, students consider GIS as providing an advantage over those students who do not use GIS. This was specifically so for presenting maps within their assessment items, some of which would inevitably be sent to District Review Panels for moderation.

Well, say they keep all our assessment and stuff for like that we hand in over the Senior Geography, the two years, and I think they give it to the um, whoever does the marking for the OP, and our presentations look a lot more professional, then we might have a slight advantage over someone who doesn't use it, who might do their map by hand (t2 p2).

I: Why do you think your teachers want you to use it; what do you think your teachers want you to get out of it?
Experience. Using GIS maps. Like getting ahead of other schools and stuff (t4 p1).

Well, say they keep all our assessment and stuff for, like, that we hand in over the senior geography, the two years, and I think they give it to the … [District Review Panel] … and our presentations look a lot more professional then we might have a slight advantage over someone who doesn't use it, who might do their map by hand (t2 p2).

> ***I: If you weren't using GIS for the [field study that you undertook], what would you do?***
> *I think we would do a really dodgy job on Microsoft Word and it wouldn't turn out as good.*
> *Yeah.*
> *You could find some map somewhere, but you couldn't do the stuff that you can do.*
> *It wouldn't be as good, because it wouldn't let you see details, like wind directions, and waves (t6 p5).*

> *P1: I would use it even if we had the choice because it makes the assignment look neat, better than some pictures pasted on there from Google or something.*
> *P2: But are we using it because we want to use it or because we have to use it?*
> *P1: I reckon we are using it because it looks neat.*
> *P3: I think it really gives an edge to the report (t6 p6).*

As previously noted, students see GIS as an alternative to the more common way of doing things in their classes. However, this is not to say that they categorically prefer to use GIS in all situations, nor that it should replace more traditional learning experiences. Rather, they see that using GIS as part of Senior Geography improves the whole of Senior Geography.

> *As I said before, there's a lot in geography, and not all of it is relevant to ArcView, but I think [GIS] is beneficial to some parts [of Senior Geography] (t10 p5).*

It does this not by taking the place of any particular classroom experience but, rather, by augmenting the multiplicity of skills and experiences gained through studying Senior Geography, as well as augmenting students' own capacities to learn these skills. This ability of students to reconcile themselves to the role of GIS as a part of their learning appeared within a number of interviews, such as the following excerpt from Transcript Eight.

P1: Can I ask a question? Which one, okay, which one do you learn better from, drawing it or on the computer? Because, if you draw it and stuff it may actually go straight through your head, because you are concentrating more, whereas if you're reading it [a map produced using GIS], you know you might just read it and it will go out the other way. So which one do you learn more from?

P2: Maybe we need to look at both situations, because if you are just sitting there drawing it you can get annoyed and think "why am I drawing this and it kind of goes through your head, and you see the end result, and the end result is seeing the map and that is how you learn the information, but that is the same end result that you get with GIS. You see the map, you print it, you look at it, and you have the same information. So, I would go "yep, I would learn the same amount by doing that map by hand or by doing it by GIS" (t8 p6).

I: Who would like to keep using it and why?

Yeah, so I can get to know it better so I can use it more in the future (t5 p5).

Further evidence of this conception of GIS as a better Geography is that students experience GIS as something that they are keen to pursue further. This is not because they believe themselves to be competent in its use. In fact, it is quite the contrary. Because students see the inclusion of GIS as constituting a superior form of Senior Geography, they are keen to gain the competency that they believe will better enable them to fully embrace the opportunities such a course of study will present, much like their willingness to learn the many other new skills that the course entails.

I: Do you think you are advantaged or disadvantaged being able to use GIS?

Advantaged to the fact that we're learning or have learnt to use it, but disadvantaged to the fact that we haven't been taught to use it more.

If we got to use it more that would be better (t5 p5).

Category Six – in summary

Students experience *GIS as Better Geography: offering a superior curriculum, and broader geographical education, when contrasted to a Senior Geography that omits its use*. As such, the referential aspect of this conception is better geography. Structurally, this conception is revealed through students experiencing GIS as being: worthwhile once you know how to use it; an efficient use of time; a presentation tool; and, a better way to do geography. Focal in student awareness of their experiences of GIS is that their use in Senior Geography improves the course and, through this, improves student prospects of success in and beyond Senior Geography.

Summary

This section has delimited the qualitatively different ways in which GIS are experienced by participants. Explanatory labels, discursive description and illustrative quotations have been presented to delineate each of the six Categories of Description and, through this, the six qualitatively different conceptions that are lived by participating students. The distinguishing features of each Category are summarised in Table 18, as are the constituent referential and structural elements of each conception.

Now that the ways in which students experienced GIS have been understood, attention will be directed to identifying the way in which these conceptions are intertwined, through construction of an Outcome Space.

Table 18.

Summary of Categories of Description.

Category Label (Abbreviated)	***Referential Aspect (what GIS is conceived as)***	***Structural Aspects (how GIS is conceived)***	***Focal Element***
Maps in Geography	GIS as maps and a source of maps in geography	▪ Greater quality & quantity of data than other maps ▪ Maps are not a separate part of the GIS program	The focus on maps is the distinguishing feature of this conception. GIS is delimited to maps as they are presented by the GIS program. Using GIS requires the use of maps.
Mapping in Geography	GIS as mapping in geography	▪ Manipulating mapped or mappable information ▪ Making maps	The focus on how maps are used in geography is the distinguishing feature of this conception. GIS is delimited as an activity that involves using maps in Geography.
Professional Mapping Tool	GIS as a professional mapping tool	▪ Beyond school need and IT capabilities ▪ Being able to do many more things than we know it can do ▪ Doing the geography for you ▪ A poor use of time	The distinguishing feature of this conception is its focus on GIS being designed for people who are more geographically and computer literate than students. GIS is delimited as an activity that is disconnected from students they see as the purpose of Senior Geography.

Category Label (Abbreviated)	*Referential Aspect (what GIS is conceived as)*	*Structural Aspects (how GIS is conceived)*	*Focal Element*
Frustrating Geography	GIS as frustrating geography	▪ Frustrating ▪ Tedious ▪ Difficult to learn ▪ Creating uncertainty	The distinguishing feature of this conception is its focus on GIS as being a frustrating way to do tasks in Senior Geography, and a way of frustrating progress toward attainment of those tasks. GIS is delimited as a disconcerting and irksome experience, which students find both academically and personally discomfiting.
Relevant Geography	GIS as relevant geography	▪ Relevant to different learning styles ▪ Relevant to Senior Geography ▪ Relevant for computer skills ▪ Relevant to life beyond school	The focus on relevance to students' immediate studies and to their future lives is the distinguishing feature of this conception. GIS is delimited as a way of doing geography that is aligned to what students see as the purpose of Senior Geography.
Better Geography	GIS as a better Geography	▪ Worthwhile once you know how to use it ▪ An efficient use of time ▪ A presentation tool ▪ A better way to do geography	The distinguishing feature of this conception is its focus on the superior nature of learning experiences and learning outcomes. GIS is delimited as improving Senior Geography and student prospects of success in and beyond Senior Geography.

Description of the Outcome Space: GIS as Experienced by Students

The way in which the various conceptions of GIS that were derived from the data analyses are logically related is graphically depicted in the outcome space (Marton, 1986). The outcome space presents two interconnected elements: referential and structural (Figure 19). The referential aspect describes the varying meanings of the conceptions of GIS and the global meaning of GIS as the phenomenon under investigation. In so doing, it describes what GIS are conceived as (Bruce, 1997); specifically, the current study reveals these referential aspects using statements commencing with "GIS is…". The structural aspect describes how GIS are conceived by illustrating how the conceptions are related; "how the phenomenon and its component parts are delineated and related to each other" (Marton *et al.*, 1993, p. 278). Moreover, Marton *et al.* add that this "structural aspect is dialectically intertwined with the referential (or meaning) aspect of the conception" (p. 278). A further distinction may be made within the structural aspects of the outcome space, whereby the relationships between the conceptions may be hierarchical or developmental (Bruce, 1997). The varying meanings inherent in each conception contribute to the position of each category in the outcome space; in other words, they provide the outcome space with its structure.

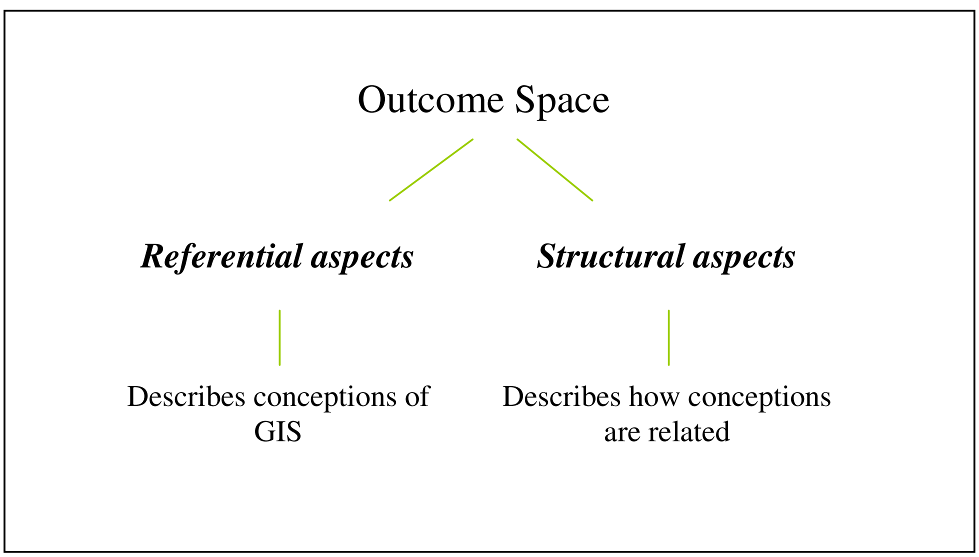


Figure 18. Elements of an Outcome Space.

The Chosen Metaphor

Following the research methodology and analysis of Mailler (2006), the six categories of description have been allocated metaphoric labels. The purpose of these is to assist the conceptions to be understood more clearly through referencing them to "concrete examples with which the reader may be more familiar" (p. 193). The labels emerged from students' discussion of their experiences of GIS, with the chosen metaphor emerging from three distinct ways in which students referred to their experiences of it. First, since discussion was largely about their experiences of geography through GIS, it is perhaps not surprising that students frequently described this using language also relevant to the discussion of maps and landscapes generally, and landscapes mapped with GIS, specifically. Second, discussion also tended to describe GIS in terms of it being a distinct feature of the Senior Geography curriculum, much like an island is a distinct feature of the broader landscape. Third, since students frequently described their experiences of GIS using language also relevant to the discussion of a journey, the chosen metaphor involves the passage of student explorers through the mapped island landscape. Within this metaphor, each category of description is discernible as a feature (or Theme) of a landscape mapped with GIS, with each feature possessing two or more distinct elements (or Attributes). The Themes and their Attributes are introduced in Table 19.

Following Nagel (2002), the outcome space will be revealed in two stages. First, the "constituent elements that are used to establish the visual representation" will be revealed (p. 224). Second, the overall visual schema that establishes the interrelationships between those constituent elements will be revealed.

Table 19.

Relationship between categories of description and the Mapped Island Landscape metaphor.

Category of Description		*Metaphor (Theme)*	*Metaphoric elements (Attributes)*	*Significance within the Mapped Landscape*
Category 1	GIS as maps and a source of maps in geography	Water sources	Reliable water sources Unreliable water sources	Watercourses provide a source of water to the student explorer, without which their progress through the landscape will be limited and difficult.
Category 2	GIS as mapping in geography	Signs	Sign posts Other signs	Signs provide guidance and directions for the student explorer to follow. The ease and reliability with which these may be followed influences the ease with which the student explorer may traverse the landscape.
Category 3	GIS as a professional mapping tool	Terrain	Level ground Undulating slopes Steep slopes Cliffs	Terrain is one variable that influences the freedom of passage for the student explorer, and determines the routes that will be taken to traverse the landscape.
Category 4	GIS as frustrating geography	Vegetation	Grassland Open forest Closed forest Jungle	Vegetation is another variable that influences the freedom of passage for the student explorer, also determining the routes that may be taken to traverse the landscape.
Category 5	GIS as relevant geography	Paths	Reliable paths Unreliable paths	Paths provide a means for the student explorer to more easily traverse the landscape, enabling passage through/across otherwise less accessible terrain and/or vegetation.
Category 6	GIS as a better Geography	Vantage points	Views	Vantage Points provide the student explorer with information about the landscape itself, such that they may better see where they have come from and better identify easier routes through the landscape. Vantage Points also enable the student explorer to see the world beyond the landscape of their immediate experience.

Three elements of the outcome space.

Emerging from the six conceptions are three constituent elements from which the outcome space is derived (Figure 20). These are:

Element One:	Physical features	–	GIS *is*.
Element Two:	Cultural features	–	GIS *does*.
Element Three:	Experiential features	–	GIS *feels*.

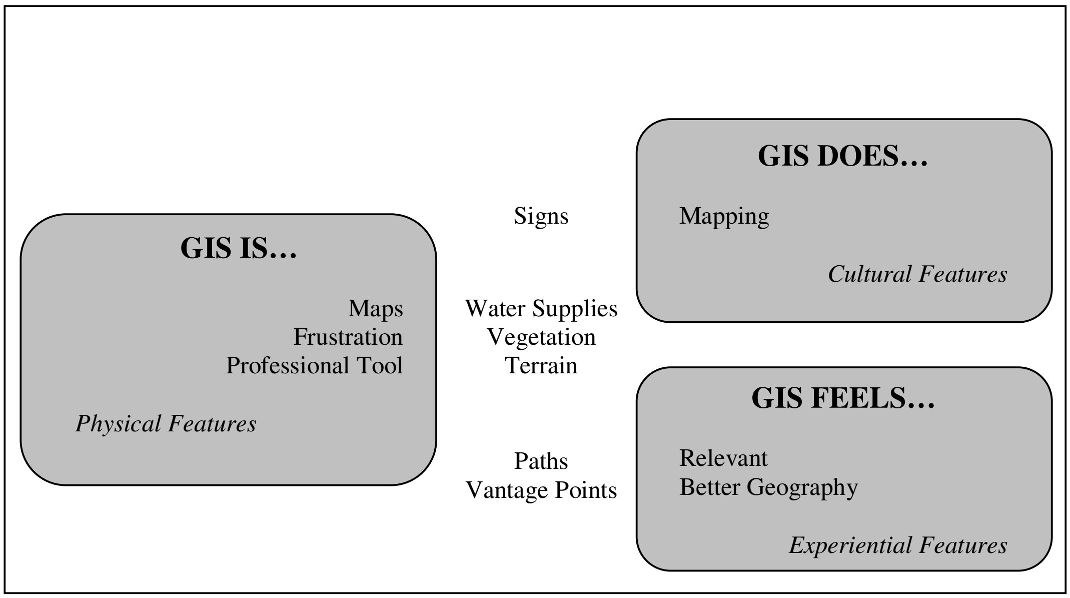


Figure 19. The three constituent elements of the outcome space.

It is appropriate now for the metaphor of each constituent Element to be described in turn, with the metaphor deconstructed to reveal the parallel student experience of GIS.

Element One

Element One refers to students' experiences of the program itself; of what GIS *is* (Figure 21). It emphasises students' experiences of GIS as reflecting their view of it as being 'easy' or 'hard', based upon their understanding of maps being its fundamental component (Category One), their efforts to learn how to use it (Category Four), and their belief that the program is beyond the capabilities and needs of Senior Geography (Category Three). Element One provides the physical landscape over which students must travel as they experience GIS. Table 20 compares students' metaphoric experiences of Element Three with their literal experiences of GIS.

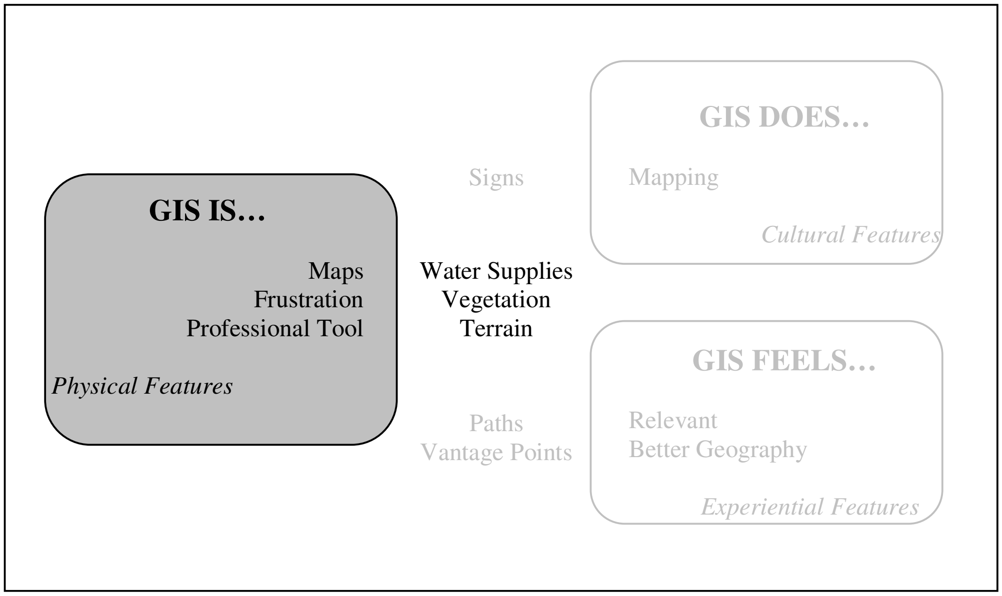


Figure 20. Element One.

Table 20.

Metaphoric and literal student experiences of Element One.

Element One: Metaphor	***Element One: Student Experience***
A critical feature of the island landscape for the student explorer is the supply of water. Forward progress can only be sustained through repeated consumption of water. Since the student explorer can only carry so much water at any one time, it is necessary for him/her to replenish his/her supplies at regular intervals. For this reason, it is important that the student explorer does not stray too far from the Reliable Water Sources on the island. Similarly, the amount of water needed by the student explorer will depend on other conditions that they encounter, such as terrain and density of vegetation. Reliance solely upon the Unreliable Water Sources is fraught with danger and is likely to impede the student explorer's journey through the island, as their capacity to endure adverse conditions on the island is limited.	The extent to which students experience GIS as being maps (Unreliable Water), or more so as a source of maps of greater quality and quantity of information (Reliable Water), influences their capacity to engage with GIS to achieve any educational goals intended for its use. Students who experience GIS solely as maps are greatly limited in their capacity to experience other aspects of GIS. This is because they are not aware of how to proceed with its use, nor does their understanding sustain their progress into new situations; when confronted by any difficulty when using GIS, these students are likely to find these to be insurmountable. By contrast, students who recognise that GIS present maps with data of superior quality and quantity are more able to persevere to experience some degree of progress through the intended learning experiences, since their understanding of GIS as a source of maps allows them to consider a greater range of possibilities than had they seen GIS simply as the maps themselves. Students experience GIS as a Professional Tool to a range of extents. For some students and some tasks, this is a benefit, for others it is no more than something about which they are aware. For others, it is insurmountable. Accessing the potential of GIS is influenced by the extent of this conception being experienced.

Element One: Metaphor	*Element One: Student Experience*
The island landscape comprises a range of topographies. Lofty peaks rise from coastal plains, with river valleys flowing from steep headwaters to gently undulating alluvial plains. Access across the island is influenced by the terrain. The coastal plains and undulating river valleys are generally accessible, and the ridges enable some ascent, whereas the steep slopes and cliffs of the highlands serve to thwart the progress of even the most ardent student explorer.	As with GIS as a Professional Tool, the degree of frustration experienced by students while using GIS influences the extent to which its goals are attained. For some students and some tasks, this is no more than something about which they are aware. For others, it is an impenetrable obstacle. Accessing the potential of GIS is influenced by the extent of this conception being experienced.
As with terrain, the density of vegetation influences the ease with which the student explorer may journey through the island. The grassland is patently accessible; the open forest, although replete with more obstacles, still allows for pleasant walking; and, the closed forest, with its dense understorey of shrubs and vines limits access to only the hardiest of student explorers. The sheer density of the jungle prevents access altogether.	The extent to which GIS is experienced as a Professional Tool and as Frustrating determines the accessibility of GIS to a student. Low levels of both offer some hindrance to the use of GIS, but do not hinder progress with its use. At the other end of the spectrum, if the experience of both Frustration and of GIS as a Professional Tool are, when combined, too great, then the student is unlikely to progress through the intended learning experiences with any substantial degree of success.
Because of the combinations of terrain and vegetation, the entire island can be delineated into regions based on accessibility to the student explorer: high accessibility; moderate accessibility; low accessibility; inaccessible (ie, cliffs).	

Element Two

Element Two refers to students' experiences of using the program; of what GIS *does* (Figure 22). It emphasises students' experiences of GIS as reflecting their view of it as being a tool, based upon their use of it to manipulate and make maps (Category Two). Element Two provides the guidance and directions in which students may travel as they experience GIS. Table 21 compares students' metaphoric experiences of Element Three with their literal experiences of GIS.

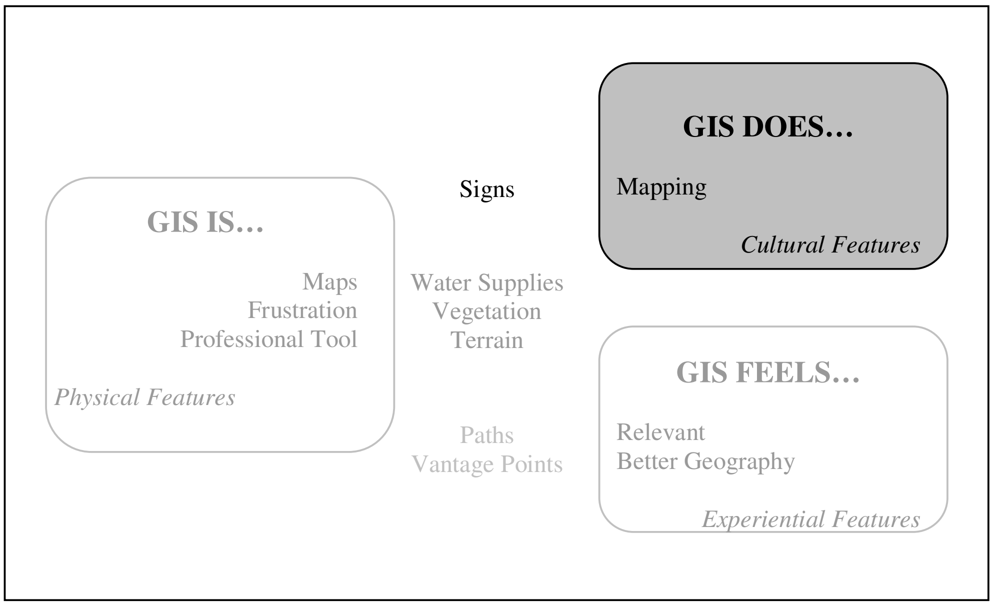


Figure 21. Element Two

Table 21.

Metaphoric and literal student experiences of Element Two.

Element Two: Metaphor	***Element Two: Student Experience***
Student explorers traversing the island will no doubt find it easier if they use the signs. Sign posts have been constructed to guide the student explorer around the island with little need for independent navigation, such that they experience from a position of relative ease a range of vegetation types, terrain and vantage points. However, the student explorer is not limited to them. Intentionally or otherwise, the student explorer may ignore or augment those sign posts and use other signs to guide their journey through areas whose constituent combinations of vegetation and terrain enable progress. These other signs could include evidence of those who have gone before, such as footprints and other evidence of human passage, other explorers' anecdotal experiences, the sound of water flowing, as well as personal preferences for a particular route. While heeding the advice of actual signs will invariably lead the student explorer to exploit Unreliable Water Sources as a part of their journey, the other signs that they may choose to follow are invariably less predictable, although these do open the possibility for Reliable Water Sources to be accessed.	Students who use GIS to undertake some form of mapping activity are likely to gain some understanding of it or from it. Using the maps that are provided (by teachers) for use with GIS gives students some exposure to a range of GIS options and capabilities, especially when this involves manipulating the information as part of a particular, pre-defined, task. However, when students are not limited to using existing maps, they may engage in making new maps. This grants them with the understanding requisite to accessing a potentially broader range of GIS options and capabilities. While manipulating existing maps offers students the most certainty when using GIS, the creation of new maps does involve more open-ended activity, albeit engendering a less certain outcome.

Element Three

Element Three refers to students' responses to their experiencing Elements One and Two; of how GIS *feels* (Figure 23). It emphasises students' experiences of GIS as reflecting their view of it as being of some personal and academic value, based upon their understanding of GIS' relevance within and beyond their immediate studies (Category Five), and their belief that its use enhances their geography studies (Category Six). Element Three provides the vantage points from which students may view other features of the island landscape itself, and view the island as a component of the broader landscape of which it is part. Table 22 compares students' metaphoric experiences of Element Three with their literal experiences of GIS.

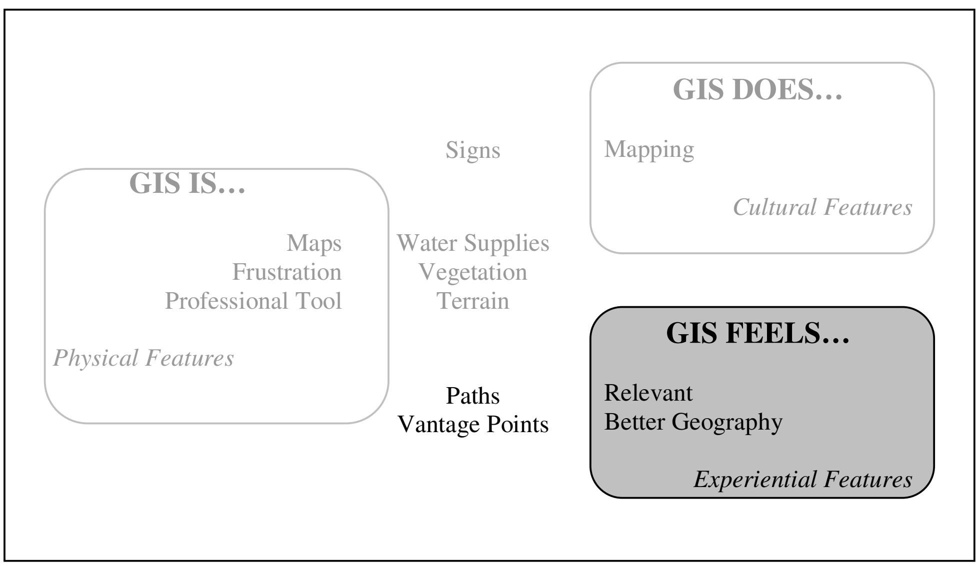


Figure 22. Element Three

Table 22.

Metaphoric and literal student experiences of Element Three.

Element Three: Metaphor	***Element Three: Student Experience***
Access by the student explorer may be aided by various Paths. These serve two purposes. First, they enable the less capable or less energetic explorer to experience some of the island with comparative ease. Second they are located at sites where aspects of the island would otherwise serve to make the forward journey extraordinarily difficult, if not impossible. Reliable and Unreliable Paths provide access through areas in which travel would otherwise be somewhat difficult, and escort the student explorer across otherwise impassable areas. The quality of Unreliable Paths is, as their name suggests, not certain, nor is their destination.	Students who experience GIS as being in some way relevant are likely to overcome challenges presented through their experience of GIS as being a professional tool and/or as frustrating. For some students and some tasks, the experience of relevance is limited to aspects of some GIS tasks, thus offsetting only a small degree of difficulty experienced through concurrently experiencing GIS as a professional tool and/or as frustrating. For others, the experience is of GIS as widely relevant, in which case their experiences of it as a professional tool and/or as frustrating are usually vicarious.
The island offers the student explorer many opportunities to avail themselves of fine views. These are located where combinations of vegetation and terrain allow for sight over parts of the island, or to beyond the island. Many of these are accessible via following the Signs and Reliable Paths, although they do not exploit Reliable Water Sources. Thus, the student explorer will be largely dependent upon whatever water they have brought with them to. Other peaks will remain permanently inaccessible to all but the most determined explorer who is prepared to take some risks with Unreliable Paths. However, given the nature of the terrain, it is not necessary for the student explorer to visit every vantage point in order to gain a comprehensive understanding of the island and beyond. Rather, should they choose their vantage points wisely, they will be able to gain an understanding and experience that will encompass (and exceed) that provided by some other (lower) vantage points, including an understanding of how they may better explore the island.	Using GIS gives students the opportunity to experience Better Geography. At its pinnacle, this comes through students being aware of what they have been doing, what they can do, and how the experience of GIS 'fits' within the larger context of Senior Geography, and life. Lesser degrees of this are experienced when students experience some understanding of what they have been doing, what they can do and how the experience 'fits' within some aspects of the larger context of Senior Geography and, to a lesser extent, life. Students who experience the former are well positioned to become capable users of GIS, being aware that GIS' processes are required to support learning, rather than vice versa. In this way, they 'rise above' and see beyond the difficulties associated with its use.

The Overall Visual Schema of the Outcome Space

The role of the outcome space is to capture logically the different ways in which the participating students experienced the relationships between these three constituent elements outlined previously (Marton, 1994). Following this, the outcome space presented here extends the metaphors used to describe those three elements; hence capturing the range of qualitative variations in students' experiences of GIS (Figure 24).

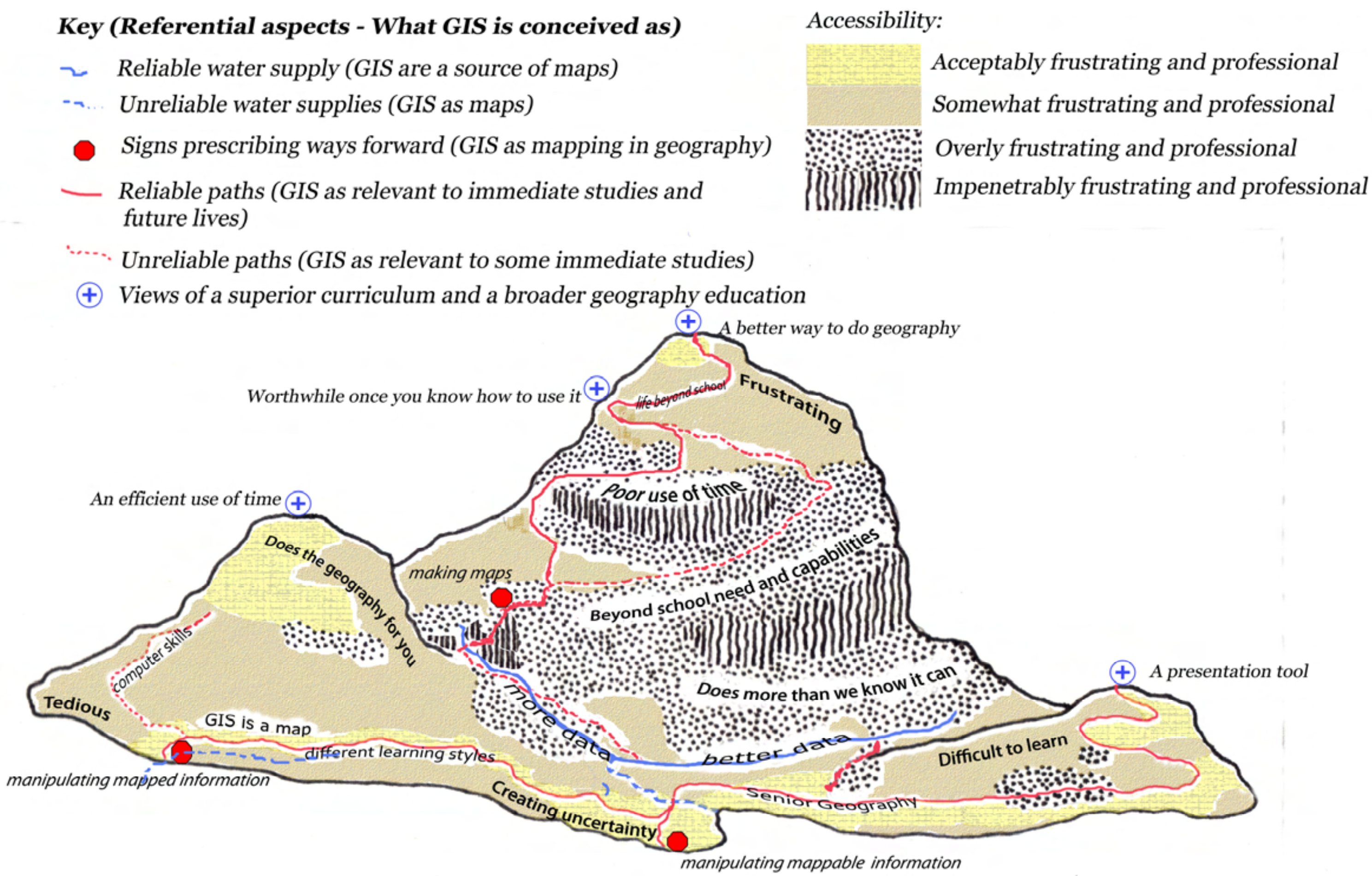
A mapped island landscape was chosen because it is commonly experienced by people as a distinguishable feature within a broader landscape, just as GIS are commonly experienced by students as a distinguishable feature with the broader landscape of Senior Geography.

Deconstructing the Mapped Island Landscape

Any landscape will comprise many features. Within a physical landscape, these will include terrain, vegetation, drainage, elevation and aspect. Within a physical landscape, these will not exist independently. Rather, their form is the direct consequence of their constant interactions through time. Indeed, a particular landscape can usually be recognised by the particular combinations of these interactions at a particular location.

The addition of cultural elements to this landscape adds further complexity, and for two reasons. First, the addition of human constructions such as signs and paths increases the complexity of the interactions between and among these and the physical features, thus influencing the future shape of the landscape. Second, the addition of human experiences of that landscape increases the complexity of human interaction with the processes that have determined the landscape's shape; thereby directly influencing the nature of future processes. In this way, the cultural elements will – intentionally or otherwise – irrevocably alter the nature of the landscape itself. Of course, an adjunct to this is that such an alteration will, also irrevocably, alter any subsequent human experiences of that landscape.

Figure 23. The Outcome Space.



Culturally and historically, the features and language of landscapes and human experiences of them have come to assume other, symbolic, meanings; used to describe other aspects of human experience such that these are communicated for better understanding. Likewise, the features and language of landscapes and human experiences of them will assist us in depicting the qualitatively different ways in which students experienced GIS.

Figure 24 captures the conceptions also as a landscape; thus also comprising a range of physical and cultural features. While the nature of their interactions results in a potentially infinite range of spatial and temporal combinations, there is evidence that these constitute a pattern of discernible landscape morphologies. The chosen metaphor thus articulates the conceptions such that they possess an internal logic from which the likely experiences associated with these morphologies can be readily understood. Indeed, it is within this form that the conceptions ought to be interpreted and it is to the pattern of discernible landscape morphologies that our attention will now be directed.

The island comprises summits, reliable and unreliable paths, reliable and unreliable water sources, formal and informal signs, and combinations of vegetation and terrain which constitute areas of differing accessibility: high, medium, low and inaccessible.

Initial embarkation to the island would usually be via one of two points, both comprising a Reliable Path near an Unreliable Water Supply, with a Sign providing initial interpretive and directive information. Apart from these two points, entry to the island may also be through landing anywhere along the shore in places of various accessibility, or it could be through descending to a similarly large range of points from the air, for example by parachute. Because of the different nature of immediate access (Paths) and information (Signs) available at the various points of entry, the initial direction taken by an explorer is equally varied.

The three summits are at different elevations. Hence, they command different views over and beyond the island. From the lowest vantage point, Summit A, the view includes detail that includes the accessibility of the other summits. Visible from Summit A is a possible route to Summit B, via an Unreliable Path and a traipse through some moderately and then highly accessible landscape, that was otherwise not visible from lower ground. However, from Summit A, Summit C appears inaccessible due to the presence of dense vegetation and steep terrain, including cliffs. A Reliable Water source is visible from Summit A as is the possible route from the main path that goes to it. Another Reliable Water source is visible in the valley that separates Summits B and C, although it appears inaccessible. From Summit B, however, it is possible to see the Unreliable Path leading not just to this Reliable Water source, but to additional Paths, a Sign and additional Vantage Point, and leading ultimately beyond the cliffs to the summit itself. The view from Summit B is greater in scope than that from Summit A, with Summit C offering the greatest vantage point of all; commanding views not just of the landscape through which access to the Summit has been gained, but of otherwise inaccessible landscapes on the island's other side and beyond its shores.

As with participants in many real landscapes, the role of students as participants within this metaphoric island is that of explorers. Significantly, however, the exploration is not an optional one.

> ***I:*** ***How often would you like to use it?***
> *P1:* *Well, if I had one of those assignments every week then I would want to use it every week. I'd use it as often as I needed to do what I had to do*
> *P2:* *But, I'm not going to go in there in my lunch time just to play with it (t7 p5)*

To deconstruct this metaphor, students experience GIS as a distinguishable component within the broader landscape of Senior Geography. The level of interest and motivation of students differs greatly, and their commitment to the stated and other goals of Senior Geography is equally variable. With respect to GIS, and although it may be external to themselves, the students' goal is to at once become familiar with GIS itself (learning *about* GIS), and through this, to become familiar with the concepts within and beyond Senior Geography (leaning *with* GIS).

The experience of students is aided by some of their experiences of GIS, yet hindered by some of their other experiences of GIS; in any case, combinations of experiences may serve to promote or thwart student progress.

> *P1: 'Cause, yeah, it's a lot more complicated, like XXX said before, because you like have to have experience to create map in ArcView GIS and (t5 p2).*

> *P2: I wouldn't say that it is totally worthless and pointless. Most of the people will say that it's just too complicated.*
> *P3: Yeah.*
> *P4: So, you don't think that, you just think that it is all complicated and you have to have experience to know what to do (t5 p4).*

Exploration of the island involves moving through it. Regardless of the route or time taken, the supply of water is essential. The amount of water required to sustain the exploration, however, will depend upon the route taken and the time required to traverse that route. Adhering to Reliable Paths, travelling short distances to only those clearly Sign-posted places, will allow an explorer comparatively easy passage through a limited variety of highly accessible terrain and vegetation. Without water additional to that which they consumed prior their embarkation to the island, however, it is likely that they would fail to reach any vantage points from where they might otherwise view parts of the island and the landscape beyond.

> *P1: We should be given examples and we should be given reasons for it; [we need to know] the 'Because' [of what we are meant to be doing]*
> *P2: I think we have sort of been pushed into it, pushed off the cliff ... because [the teacher] hasn't given us a manual for it, but I think that if we explore it for ourselves then, we know it's hard, but I think we'll get a better understanding of it in the end*

P3: I don't even know what it is at all, I just do whatever he says because I don't know what GIS is really meant to be or for, so I just do what he says and I don't know why he says it, and I don't worry about it because if I worry about it I just confuse myself.

P4: This assessment piece, the criteria was to show a map that showed the breakwater, [the teacher] didn't give us or say that you can make a map, or what sort of map, so we just did what we're told to do because that's what [the teacher] wanted

P5: And I need to have someone to come in and come in to explain what its basic parts are and what it does for us.

P6: The thing what I think of that is that a lot of the stuff that someone says and its technology, and if you're not very familiar with technology yourself, and they tell you all this stuff that you should do this and you should do that, then I think it just goes straight over your head. I mean you might get some of it, but the other stuff just goes.

P2: I reckon you should get someone to go in there and show you themselves, like hop on the computer and show you.

P5: But I forget, that's why I think you need a manual to say that this is what you do because and blah blah blah and have each step done really detailed, so then when you look at and say I want to do this, you can then look at it and find out how to do it (t6 p6).

Alternatively, the breadth of an explorer's experience of the island may benefit from moving beyond the sign-posted Paths to explore other routes. By utilising Other Signs, such as their own prior experience and/or other explorer's anecdotal experiences, footprints, considering the sources of water available to them at different locations and times, and avoiding inaccessible combinations of dense vegetation and steep terrain, this explorer will be able to traverse a variety of landscape morphologies, and exploit water supplies not otherwise accessible via the Reliable Paths, and which themselves traverse those more impenetrable landscape morphologies. Although this route-making will present more obstacles than experienced by our first explorer, it also presents motivational benefits that remain unknown to them. By doing so, this explorer will experience a greater variety of the island's geography and can reach Vantage

Points which not only afford greater views of the island and beyond, but afford them with information about the island that may be used to inform its further exploration.

Such variations in the experience of explorers results in quite different understandings of the island and its place within the surrounding landscape, and they represent disparate ends of the exploration experience.

> *P1: It's f**ked up*
> *P2: I don't understand it*
> *P3: … I hate that program (t10 p1).*

> *It gives a really good insight into the town that we live in. We learn more about it (t2 p3).*

> *It is exciting really. It's hard not to have it once you've got it (t8 p8).*

However, they do serve to illustrate the different experiences of students engaging with GIS. Typically, explorers will enter the island at a predetermined place, at which point they will drink some water which they brought with them. This water will sustain their passage until it is replenished during the exploration. Failing to replenish the water, or only obtaining water from the most accessible - Unreliable - supplies, will limit the extent to which the explorer may travel. In turn, this will limit the breadth of experience that the explorer will gain of the island.

Perhaps paradoxically, accessing Reliable water supplies requires divergence from the Reliable Paths and the exertion of greater effort by travelling further distances, and along Unreliable Paths through less accessible landscapes. For the explorer committed to the goal, this additional exertion is a worthwhile expense to enable the exploration to continue and to proceed beyond the already known elements of the island. Doing so affords the explorer more information about the island's landscapes, and more confidence and skills to traverse areas that may - at first sight - appear somewhat impenetrable, including reaching summits that, based on early experiences of the island, were insurmountable. Hence, by applying more effort, and being committed to the exploration's goal, an explorer may gain the understandings, experience and skills that enable the goal to be attained better.

Extending the metaphor

The preceding discussion considers a wide range of implications for geography education, and the use of GIS by geography students. However, the extent to which these implications are a reality for all students is not known. This is because the findings of this study represent an exploration into the wider conceptions of GIS held by students, rather than specific understandings and their development that individual students may or may not gain from engaging with it.

Having said this, it is possible to extend the metaphor to allow some tentative groupings to emerge from within the findings. The groupings may assist to furthering understanding of students' experiences of GIS in Senior Geography, and of the pedagogical implications of GIS' role in Senior Geography. While there are, no doubt, many more combinations of experiences within the island landscape, the following four groups reflect distinct combinations of conceptions and descriptive data that relate to student experiences of GIS.

To understand the extent to which using GIS may allow students within these groups to gain the spatial awareness suggested above as being requisite to experiencing success with GIS, it is worth employing the outcome space to identify possible causal effects for these four groups. For clarity, then, the outcome space metaphor will be extended to understand the likely experience of each group of students.

Group One presents a negative experience of GIS and makes references mostly to lower-order KGIs. These students may have experienced a difficult introduction to the metaphoric island landscape, including being thirsty on arrival. It is quite likely that they arrived at a different time and/or at a location on the island that was otherwise inaccessible by conventional means, with little understanding of their purpose for being there. These students struggled to make sense of the landscape in which they found themselves and travelled slowly along Reliable Paths through the island rather than seeking to strategically position themselves to be able to reach a particular destination. If they did reach the most accessible vantage point (Summit A), they will have observed the majority of the island as inaccessible due to a combination of terrain and vegetation. Their focus on simple survival precluded their concentrating on discovering Other Signs which may have provided some clues for more successful exploration. For these students, the aim was simply to rejoin their group and survive until such time as they were released from the island's captivity.

Group Two presents a positive experience of GIS and makes references mostly to lower-order KGIs. These students may have experienced a clear pathway through the metaphoric island landscape. These students will have entered the island via a Reliable Path and will have been led through the more professional and frustrating aspects of GIS' use to experience a pre-determined level of success, such as a nearby Vantage Point offering limited views. The uncertain confidence of the group leader prevented these students from travelling independently of the group; the group's size meant that not all students got the opportunity to use the equipment that would have enabled more independent route planning; and limitations of time prevented these students from more independently experiencing the wide range of cultural and physical landscapes available on the island. Because of this, the students had a lovely day out with their peers, but did not fully experience the scope of GIS' applications within and beyond their studies, thus leaving them dependent upon the prescriptive approach to GIS tasks.

Group Three presents a positive experience of GIS and makes references to both lower and higher-order KGIs. This group may have experienced a fuller array of learning experiences using GIS than other groups. This commenced with an introduction to the island and its landscape prior to arrival, and some preliminary planning which involved clear directions to enable students to understand those landscape elements which may thwart their progress. Thus, they were fully hydrated upon arrival at a predetermined location, from where the group leader provided opportunities for students to move with increasing autonomy on and off the Reliable Paths to explore the island. The island's features and suggested ways of traversing the island were described to students by the leader using a variety of means; for some, this was in person; for others, it was through pre-printed materials; for others still, it was provided but not used by students. The students of Group Three reached different points on the 'island', and therefore some more clearly saw the immediate and further benefits of its use than others. But, since they were all able to explore the island in a way that catered to their own capabilities, all had a positive experience of the landscape.

Group Four presented a negative experience of GIS and made references to both lower and higher-order KGIs. Students from this group may have been unaware of the presence of an island whose summit was attainable, and whose surrounding landscape was visible. Nor may these students have been aware of those elements of the island which may assist them in their journey, presuming that they were aware that their journey possessed a particular destination. In this regard, these students will have been exposed to spatial phenomena and KGIs, but they arrived at the island with great thirst. Accordingly, the extent to which they engaged with the island's morphologies was limited by the other obstacles that they faced, such as the seemingly relentless topography and vegetation. For these students to gain some understanding of the higher-order KGIs suggests that these elements of the island were not impenetrable. Rather, they presented an obstacle, but one that was not worth the effort to overcome.

Evident from this discussion is that, just like their experiences of exploring a landscape, students' experience of using GIS as a part of Senior Geography, is a product of:

1. their vicarious interaction with it;
2. their direct interaction with it;
3. their knowledge and understanding of the processes that have and will shape it; and,

4. the value to which they ascribe it and to which they ascribe their further experiences of it.

Chapter Summary

This Chapter has explored the various and complex meanings of GIS held by Senior Geography students. Six conceptions of GIS held by the 109 student participants have been declared and their relation to each other has been illustrated through an Outcome Space. The findings reveal that students may experience GIS in up to six qualitatively different ways which, despite their relationships, possess critical differences that serve to frame a student's overall experience of GIS.

The conceptions and outcome space have been depicted using an island landscape metaphor so that students' experiences of GIS can be understood in language used by the participants themselves during their discussions of them. This metaphor comprises a number of constituent elements which have been arranged to provide an internal logic to reveal the many ways in which the six conceptions can be related, and experienced by students.

The following Chapter will discuss the implications of these results with respect to the nature and place of geography within school curricula, and of the potential role that GIS may play within a geographical education. It will conclude with a reflection on the method and recommended directions for future research.

CHAPTER FIVE

DISCUSSION

Education has a history of regularly adopting new ideas, but it has done so without the wide-scale assessment and scientific research that is necessary to distinguish effective from ineffective forms" (Hempenstall, 2007).

Introduction

This investigation employed a phenomenographic method to identify the qualitatively different ways in which a group of students experienced GIS. This involved an exploration from the second order perspective, whereby the central phenomenon and specific research question intended to identify not the phenomenon - GIS - itself, but the experience that students had *of* that phenomenon.

The central phenomenon and research question for this study emerged from a review of literature. The relevant literature was based upon assumptions drawn primarily from a first order perspective *about* the nature and place of geography within school curricula, and of the potential role that GIS may play within a geographical education. It was the intention, then, of this research to clarify the authenticity of many of these assumptions, by explicitly investigating students' experiences.

In this regard, the following discussion seeks to clarify the potential role of GIS in geography education by melding the research findings with the reviewed literature. For clarity, the discussion will largely mirror the organisational sequence – and include the associated diagrams - found in Chapter Two. First, it will review the findings with respect to their implications for Focus I, The Nature of Geography Education, including: geography itself; its multidisciplinarity and interconnectedness; its emphasis on skills; its emphasis on problem solving; its role in citizenship and participation; and, its place as a misunderstood subject. The discussion will then consider the findings with respect to their implications for Focus II, Geographical Information Systems, including: its links to student learning; and, issues affecting its use. The Chapter will conclude with a reflection on the method and its limitations, and directions for future research.

Research Outcomes

This research clearly contributes to addressing the questions that emerged from the review of current literature (Chapter Two):

1. While involved in GIS-related tasks, *some* students do integrate information from a map to identify patterns/relationships that are not explicitly labelled.

2. *Some* students did extend their understanding of spatial phenomena to include both an awareness of pattern, trends and land-people interactions, and the analysis of information to determine reasons for these trends and patterns.

3. While involved in field tasks, *some* students augmented the information provided with the GIS with information that they gathered themselves. By adding these data to the GIS, students not only integrated mapped information, they collected and added mappable information to it.

4. *Some* students were capable of arranging multiple sets of data as discrete, yet spatially uniform, layers: the initial GIS-based data, and their own (primary) data observations.

5. Comparing the placement of the elements of each layer, in conjunction with the other understandings that they possessed (e.g., from class work), enabled *some* students not only to determine possible reasons for the patterns that they had identified (deduction), but to draw conclusions and make generalisations (induction) about the map's features.

6. The nature of the tasks described by participants, and many others in Senior Geography, is such that the phenomena being studied while using GIS necessarily draws its information from a range of disciplines, e.g., town planning, geomorphology.

7. Beyond its evident role in exposing students to the development of spatial awareness, the manner in which the participants used GIS to ultimately resolve issues and to make decisions regarding the future of the phenomena being investigated clearly aligned with the geographical route of inquiry.

8. The combination of several of the above points further indicate that, while using GIS, *some* students do:

   a. think graphically, by engaging in skills of information processing, reasoning, inquiry, creative thinking and evaluation.

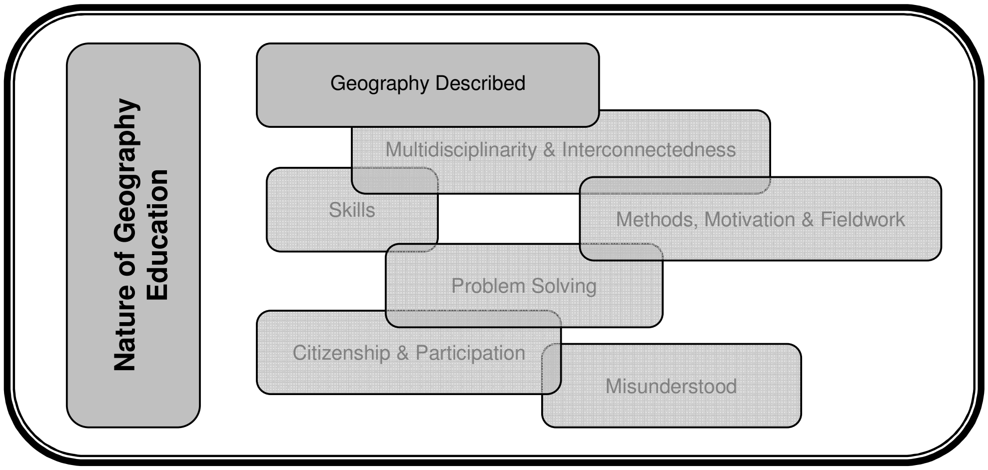
   b. better understand the world that they live in; and,

   c. see value in subject Geography.

Each of these findings will be discussed further as part of this Chapter.

The nature of geography

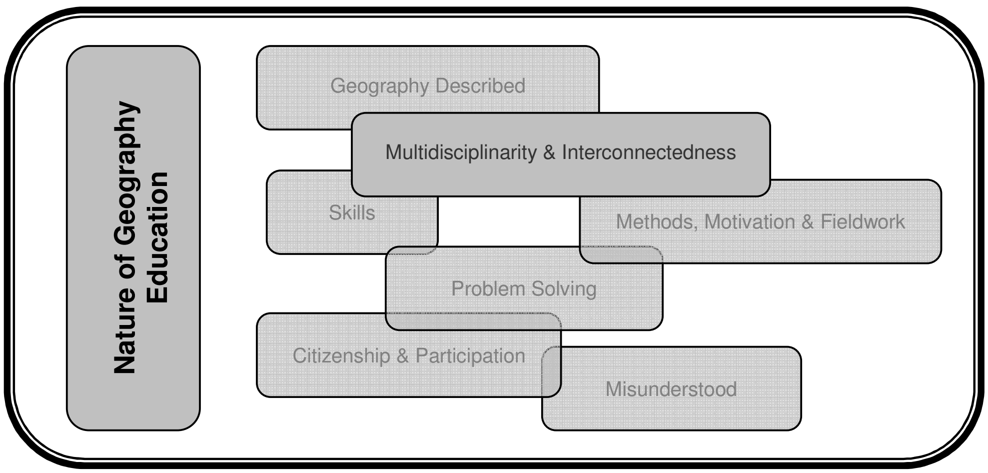
Geography Described



Review of relevant literature revealed four common elements to geography's many definitions: location; pattern; distribution; and, land-people interaction (Gerber, 1997). Its "distinctive feature" is its emphasis upon skills, their development and application (Rawling, 1997, p. 11). Review of the findings reveals that references to all four elements emerged through student discussions of their experiences of GIS. Furthermore, and revealed by Conceptions Five and Six, it confirms that students clearly experience GIS as augmenting the emphasis of geography on skills. Conception Five, *GIS as relevant within and beyond the school experience,* revealed that using GIS as part of Senior Geography can provide a framework for students to make sense of the spatial data that they encounter within their daily lives, thus aligning the GIS-inclusive curriculum with the role of geographers. Moreover, Conception Six, *GIS as a better geography: offering a superior curriculum, and broader geographical education, when contrasted to a Senior Geography that omits its use*, revealed that the value of these aspects of the subject enables geography's value to extend beyond itself, enabling geography students to describe and attempt to explain patterns evident within human-natural environments.

Accordingly, the findings suggest that using GIS meets Marran's (2003) five reasons for the continued existence of geography education and, by corollary, the continued existence of Senior Geography within the Queensland curriculum. First, using GIS enables students to experience a spatial perspective that is not provided in any other discipline (Conceptions 1 and 2). Second, it describes and seeks to explain changing patterns (Conceptions 2, 5 and 6). Third, it emphasises problem-solving in real-world contexts (Conceptions 5 and 6). Fourth, it provides an effective context for life-long learning (Conception 6). Finally, it provides students with the opportunity to develop a perspective of the world from scientific and humanistic viewpoints (Conceptions 5 and 6). Each of these will be revisited during this Chapter.

Geography: its multidisciplinarity and interconnectedness



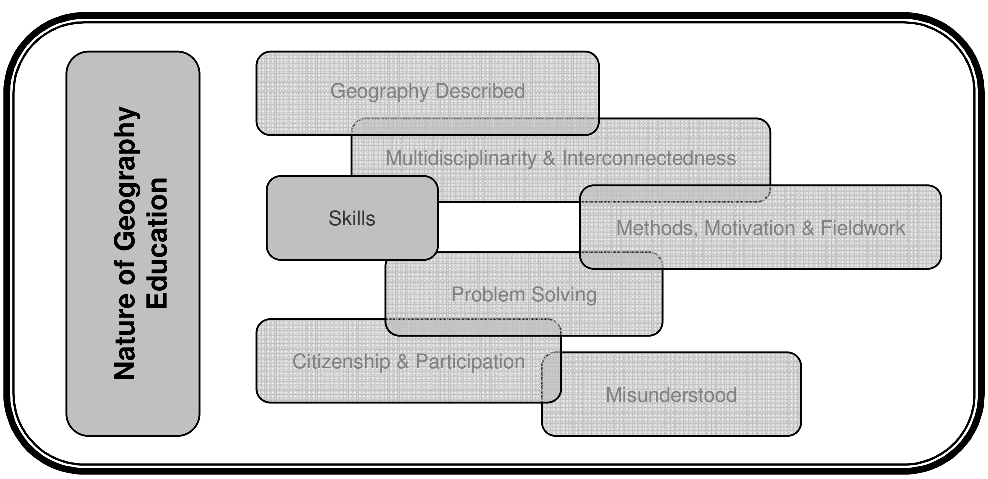
By enabling an interdisciplinarity and diversity, the findings suggest that using GIS supports Rawling's (2000) claim that geography provides a "socially critical classroom pedagogy" (p. 210). This arises from students experiencing GIS as a phenomenon which had applications *beyond* the geography classroom and which, therefore, included some of those applications *within* the geography classroom (Conceptions 3, 5 & 6)).

In this respect, by synthesising other, science and humanity, disciplines, using GIS has enabled students of Senior Geography to experience one of the three reasons for which the International Geographic Union (1997) claims geography to be unique. While describing their experiences of using GIS, many students made it patently obvious that its use enabled the use of ideas of other, discrete, subjects (including those in which they themselves were enrolled). Specifically within Conceptions 5 and 6, these experiences of GIS enabled students as part of their studies of Senior Geography to move toward the synthesis of knowledge in a more holistic sense than they may have otherwise achieved.

This experience of GIS as a multidisciplinary phenomenon supports the view that the Senior Geography syllabus is convergent in nature, encompassing other disciplines. Additionally, GIS was commonly used by students who investigated local issues to contextualise and personalise their studies of the regional and/or global processes of which those local issues were part. By doing so, using GIS in this way engendered an element of interconnectivity, the emphasis of which was encouraged by IGU a decade ago (1997), and the recognition of which is a precursor to students' deeper understanding (Murphy, Morrisson & Conolly, 2001).

Whereas GIS have been used as a part of the four Themes, and at all scales of study, prescribed by the Senior Geography syllabus, this did not occur in a uniform manner across the participating schools. Rather, the unique ways in which GIS have been used by participating schools suggest that the provision of school choice in developing studies to "select appropriate topics and case studies, to match the interests of their students, the availability of resources, and local conditions" (Queensland 1999a, p. 13) has facilitated its inclusion to aid in the attainment of syllabus objectives.

Geography and its skills



That contemporary geography education has moved beyond an emphasis on place-name knowledge and toward an emphasis on method was discussed in some length in Chapter Two. Hence, attention will now turn toward an exploration of the possible role of GIS in contributing to student development of the thinking skills that are increasingly emphasised by geography. Specifically, this section will evaluate the findings to discuss the role of GIS in student development of what Gerber (2001) sees as five prerequisites to their success in geography education.

With respect to the first prerequisite, geographical knowledge, four of the six conceptions (1, 2, 5, 6) comprised at least some element of geographical knowledge being experienced as part of using GIS. Specifically, the majority of the KGIs referred to by students were the lower order ones to which this geographical knowledge refers, such as Location, Distribution and Distance. In this regard, using GIS was aligned with the experience of geographical knowledge and, for most participants, its further development.

With respect to the second prerequisite, cognitive skills related to that knowledge, two of the six conceptions (5 and 6) comprised at least some element of the cognitive skills related to the above geographical knowledge being experienced while using GIS. However, despite their presence, only a small number of the higher order KGIs to which these cognitive skills refer emerged within the findings, including Spatial Association, Spatial Change Through Time and Spatial Interaction. In this regard, using GIS was not strongly aligned with the experience of geographical thinking.

This aspect of students' experiences of GIS supports Oldakowski's (2001) view that understanding the spatial perspective (of the phenomena under study) is necessary to understand more complex concepts and to utilise geographical technologies, such as GIS. The findings make it clear that students lacking an understanding of the spatial dimension of the phenomena being studied with GIS experienced the greatest obstacles to exploring the metaphoric island; it was these students for whom Conception Three (Professional Tool) and Conception Four (Frustrating) appeared to be most prominent. By contrast, students for whom an understanding of that spatial dimension was evident were those more likely to traverse more of the island and experience Conceptions Five (Relevant) and Six (Better). This is an outcome that matches Oldakowski's (2001) finding of a correlation between creating and analysing maps, and understanding the spatial perspective. Of course, the question remains of whether it was the manner in which the students used GIS that influenced the spatial thinking that afforded them with these experiences, or their higher level of spatial understanding that influenced their use of GIS that afforded them with these experiences.

With respect to the third prerequisite, fieldwork as the basis for learning, most students experienced GIS, at least in part, as an element of field studies. Further discussion of this role will occur later in this Chapter.

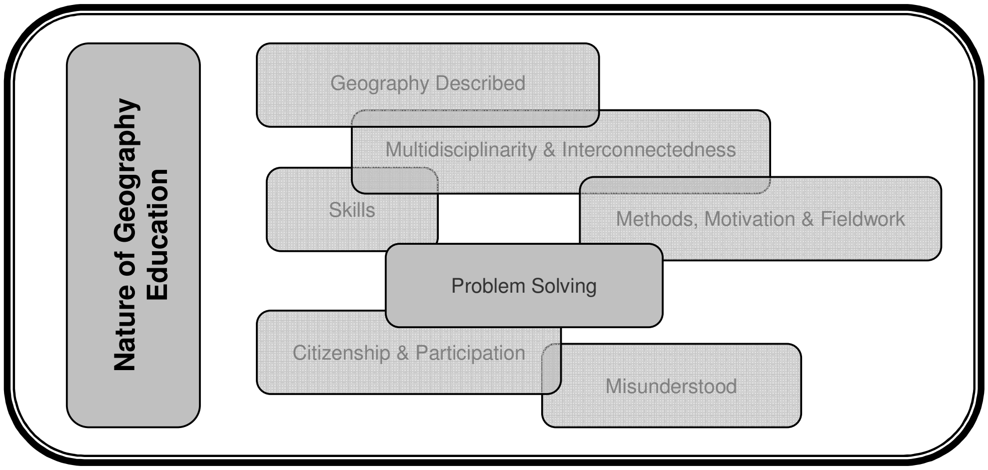
With respect to the final prerequisite, the use of maps, it is clear that students experienced GIS as a type of map/s or as a tool for mapping. Specifically, Conception One, *GIS as maps and a source of maps in Geography*, revealed that students experience GIS as source of maps which were of higher educational quality than those otherwise available within their studies of Senior Geography. However, the other component of this conception, GIS as maps, is of some concern in so far as it precludes from student experience the separation of GIS from the maps that it generates. Such a separation indicates there exists some evidence that the spatial dimension of the data being manipulated by the GIS is divorced from the maps that are subsequently presented by it. Also related to student development of this prerequisite is Conception Two, *GIS as mapping in Geography: a way to use and create maps.* Students experiencing this conception used the maps in GIS to engage in geographical thinking and the development of geographical knowledge. However, the extent to which this conception of the activities' spatial dimensions was experienced was limited by the conception of the maps as being *in* the GIS, rather than being a product *of* it (Conception One). This was particularly limiting given that there exists also the conception that making maps using GIS simply involves recreating something that already exists.

On the basis of the above, and given that just experiencing a combination of Gerber's (2001) four prerequisites will lead to success in a geographical education, then it is clear that the inclusion of GIS within Senior Geography potentially has considerable merit. Specifically, GIS could lead Senior Geography to develop in students the capacity to achieve what Fernald (2002) claims to be the aim of geography: "the analysis of the areal distribution of a phenomenon [that involves the examination of] the location and distribution of phenomena in space, or place, by means of identifying their density, pattern, diffusion, and dispersion" (p. 126).

However, arising from the conceptions that reveal some misunderstanding about the manner in which GIS manage spatial data, there do exist serious limitations to the extent to which these capacities may be developed in students. This aspect of the findings confirms Gritzner's (2002) claim that "the spatial method of organisation and analysis is geography's most essential element" (p. 39). Here, students in the present study who failed to grasp what Oldakowski (2001, p. 249) considers to be the "building blocks" of spatial awareness, the data, experience difficulty in advancing beyond the simple definition of location, and into the more demanding descriptive (e.g., distribution, area) and conceptual (e.g., interaction, association) aspects of spatial thinking.

Hence, GIS could well be implicated in students experiencing some success in a geographical education. Having said this, however, whether using GIS as part of a curriculum is more beneficial than those activities that would otherwise fill lessons remains unanswered.

Geography and problem solving



Queensland's Senior Geography requires that issues be investigated such that their study leads to the "selection between valid alternatives and making judgements supported by evidence" (Queensland 1999a, p. 46). To achieve this, however, it stipulates that material ought first to be broken "into its component parts so that students can identify trends, similarities, differences and patterns" (p. 46). The materials to which the syllabus refers are data. And, it is those very data that teachers of the participants in this research intended that their students would engage with through and while using GIS.

Evident from Conceptions Five and Six is that students can and do make decisions about the geographical issues that they have investigated while using GIS. Also evident from the findings is that these students did so through the manipulation of the spatial elements that they identified through their experiences of Conceptions One and Two. This appears to be a critical determinant in the success of students in using GIS for solving problems: where students experience solving problems as *reforming given problems* (Silver, 1994, emphasis added).

To do this requires students to transform rather than eliminate the spatial elements that constitute a given problem. And, it is here that the creative aspect of geography comes to bear: students are required to make new meaning of the spatial elements by re-arranging them in space. For the students by whom GIS' data handling and manipulation functions are clearly understood, this is achievable and offers further motivation to overcome any of the obstacles presented through their experiences of Conceptions Three (Professional Tool) and Four (Frustrating).

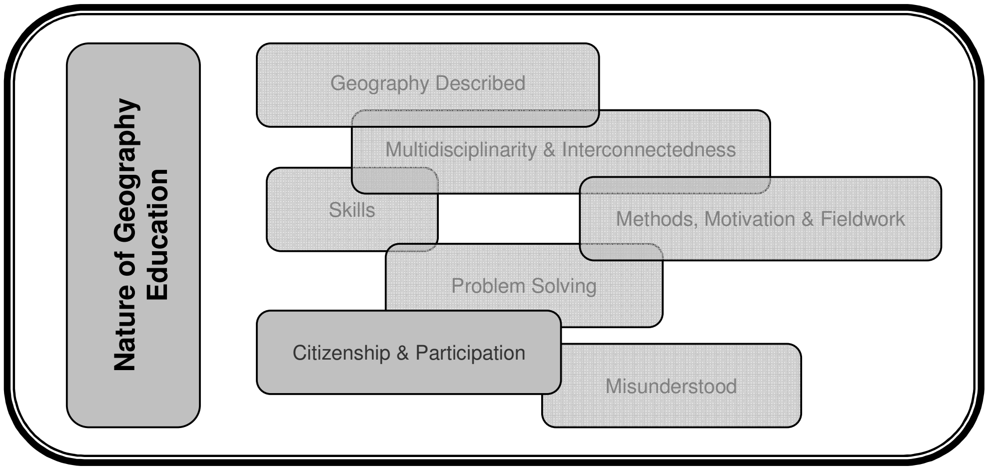
However, as with the use of maps an inability of students to identify these spatial elements within the GIS-maps that they use precludes them from identifying the potential for those elements to be transformed. Experiencing GIS as maps (Conception 1), and experiencing GIS as the re-creation of something that already exists (Conception 2) thus belies the most basic spatial element, the datum, an understanding of which is necessary to develop the core of geography: problem-solving skills.

Without this understanding, students could not successfully engage in the geographical route of inquiry. This is particularly important for the present investigation of students' lived experiences of GIS within geography education. If students fail to grasp data as the basic building block of the GIS, then they are less likely to recognise that the data presented to them is other than static. Not recognising that data may be transformed, and assuming that there is a correct answer to a given investigation will present great obstacles to the students' attempts to proceed through a geographical inquiry, whose very aim in Senior Geography is to "investigate issues about which there is no consensus" (Queensland, 1999a, p. 6).

Because of this experience, such students are likely to apportion some responsibility for these difficulties to GIS itself. It is in this context where Conception Three, *GIS as a professional mapping tool: exceeding the needs of Senior Geography*, is particularly relevant to the current discussion. Of the four structural elements of this conception, three relate to the software itself being somehow inaccessible or incompatible with what students believe they should be doing. The fourth structural element, *GIS as a professional mapping tool through doing the geography for students*, is also relevant, but for a different reason. For these students, this element relates to their experiencing GIS as performing for them the tasks that they believed they would otherwise be doing by hand. In this, some of their conceptions of GIS prevented students from proceeding through a set task, because it was responsible for the maps that formed the basis of that task. It is a simple syllogism: GIS presented students with data; students had difficulty making sense of the data; students had difficulty experiencing using GIS functions to manipulate the data; students had difficulty experiencing success in the set tasks; students experienced GIS as an obstacle to their learning. Quite simply, not grasping the basic level of GIS data handling prevented students from understanding the fundamental cause of their own difficulties while using GIS; while they were looking for GIS to provide the solution, they overlooked the role of GIS in assisting them to devise a solution.

Likewise, the above scenario includes the experience of Conception Four, *GIS as frustrating Geography: irksome and presenting many challenges to the student-user* also. These experiences arose from not understanding the role of GIS in supporting the transformation of data that was needed to engage in the spatial thinking that may or may not lead to decision-making. Instead, the experience of Conception Three becomes intrinsically linked with Conception Four, with the latter being the affective response to the former. In this regard, students who are able to recognise the data held within GIS as being transformable are less likely to experience Conception Three in a negative way. Rather, their experience of this conception emphasises the structural element, *doing the geography for students*, but from the point of view that GIS can complete the tedious aspects of geography, such as visually communicating the outcome of an inquiry, to a higher standard. Similarly, there exists the conception of experiencing success when proceeding through the route of inquiry while using GIS, and thus experiencing direct and indirect benefits of its use (Conceptions 5 and 6).

Geography's role in the world: citizenship and participation



If "much of geography's power lies in the insights it sheds on the nature and meaning of … the landscapes that make up the world in which [students] live" (Murphy, Morrison & Conolly, 2001, p. 42), then using GIS as a part of Senior Geography clearly offers the potential to equip students to better understand and interact in their worlds.

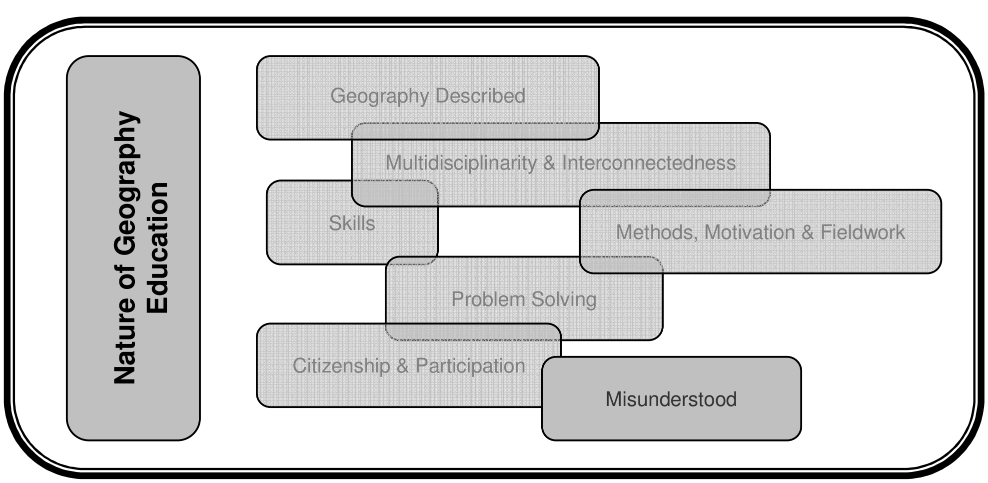
The contribution of GIS to developing in students the abilities to "participate as active citizens in the shaping of the future" (Queensland, 1999a, p. 6) - one of the seven aims of Senior Geography - comes from its use to investigate the spatial dimension of observed phenomena. Given that this aspect of geography is frequently cited as an argument for its position as the ideal place for a comprehensive global education within a school's curriculum (see, for example, Murphy, Morrison & Conolly, 2001; Rawling, 2000), students whose experiences of GIS emphasise Conceptions Five and Six over Conceptions Three and Four may well be exercising these abilities.

Specifically, the combination of the relevance that students experience (Conception 5) and the benefits of a geography education that students experience (Conception 6) demonstrated the capacity of using GIS to inculcate in students the development of citizenship and participation. The inclusion of GIS in the study of local area issues, but as part of the regional and/or global study of the processes influencing those issues, at once enabled students to experience relevance of their immediate studies, and to experience relevance of their immediate studies to their lives beyond the classroom (Conception 5). This at once enabled students to experience an improved geography curriculum, and to experience an improved understanding of the world beyond the curriculum (Conception 6).

Students who experienced those aspects of GIS have engaged in what Cox (1997) described a decade ago as meaningful learning, the need for which he argues cannot be exaggerated. Furthermore, by linking student investigation of local issues with global processes, geography became expressed within their private lives. Indeed, regardless of their success in these investigations, since all students experienced Conception Five to some extent, they will all have "in a humble way" developed their sense of personal identity (Spencer, 2005, p. 305).

And yet, for students to develop capabilities in the geographical thinking that is fundamental for citizenship, they must first develop an understanding of the KGIs that arise through the geographical route of inquiry (Fernald, 1996). Failing to develop these understandings prior to or while using GIS is thus likely to preclude a student from experiencing what many authors laud as the potential of geography to promote life-long learning (Chiodo, 1997; Downs, 1994; Gerber, 2001; Miller, Keller & Yore, 2005). In this regard, students who do not experience the spatial dimension of GIS may not develop geographical literacy and thus, according to Howitt (2002), impose "a significant burden on the nation, its communities, environments and neighbours" (p. 7).

Geography: a misunderstood subject



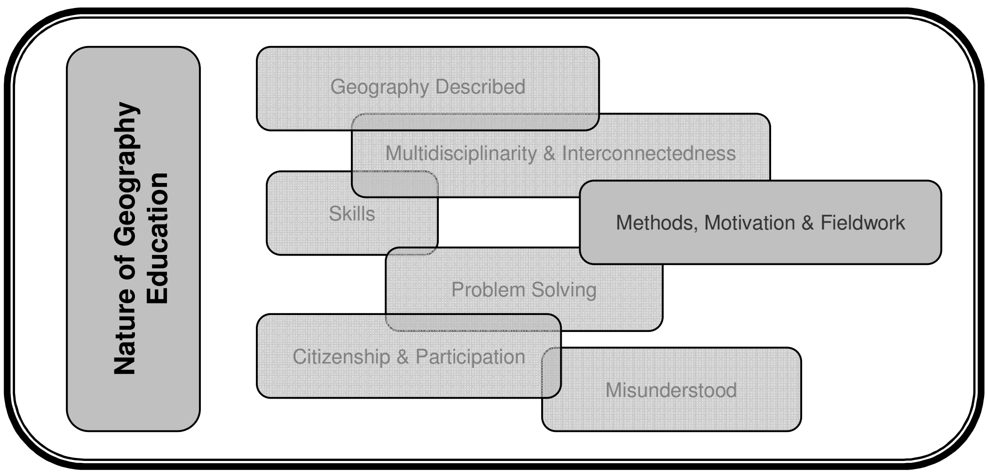
Review of the literature revealed misunderstandings about the nature of geography to be related largely to a presumption that the subject is about where things are, rather than being about the processes that explain why or how those things came to be there and the significance of those and subsequent processes for their future. The findings indicate that students' experiences of GIS can either compound misunderstanding or compel understanding of what geography is.

Students for whom spatial awareness was developed prior, with or during the use of GIS appeared to be those most likely to negotiate the route of inquiry successfully using it. There exists some evidence that GIS enable them to explore local issues within a regional and/or global context, and in such a way that they were at once developing skills in geographical thinking, generally, and problem-solving, specifically. Because such investigations occurred within a context of human-environment interactions, they were likely to be progressing toward devising solutions and making decisions that reflected not only the spatial dimension of the issue under study, but the multidisciplinary context in which those spatial phenomena existed.

Of course, where such awareness existed neither prior to nor during the use of GIS, attempting to negotiate the route of inquiry while using GIS was a likely contributor to the conception of GIS as frustrating (Conception Four) and the conception of GIS as a professional tool unsuited to a school audience (Conception Three). This was related to the conception that the aim of set GIS-related tasks, vis à vis the making of decisions to resolve issues, was overshadowed by the conception that completing such tasks required them to somehow replicate the 'answer' that they believed their teacher required of them. Because of this, such students were likely to perpetuate the concern expressed by Murphy, *et al.*, (2001) that geographical problems were not being solved through consideration of their spatial dimension. Instead, students were likely to offer inappropriate solutions which, were they to be employed, may serve to exacerbate rather than ameliorate the issue being investigated.

Hence, with respect to GIS' role in addressing the misunderstanding of geography, it is evident through the findings that students for whom the spatial dimension of GIS was clear developed a more clear understanding of geography and that this offered them a view of geography's broader applications (Conception 6), within which they could undertake subsequent geographical activities. The corollary to this, of course, is that students for whom the spatial dimension of GIS was not clear spent their time on the island making little progress as they attempted to cut a swath through dense vegetation on steep slopes.

Teaching Geography: Methods, Motivation and Fieldwork



Methods

The rise of ICT's prevalence within society, generally, and education specifically, has presented some challenges to geography curricula. The use of contemporary GIS software as part of those curricula represents a response by some teachers to this rise. However, while ICT (including GIS) have increased both what we know and the rate at which we acquire more knowledge about the earth (Gritzner, 2003), the findings do not clearly indicate that using GIS as part of Senior Geography will enable students to experience these efficiencies.

It is apparent that there are many proponents for the widespread use of ICT as a vehicle by which individual subjects may better achieve their goals. However, there remains uncertainty about what leads students to bridge the gap in the spatial understanding that is represented by Conception Three (Professional Tool) and Conception Four (Frustration). Specifically, the findings do not indicate whether a certain degree of prior spatial awareness is required to successfully use GIS, thus bridging that gap and experiencing the relevance of GIS (Conception 5), or whether the requisite spatial awareness can be adequately developed while using GIS.

Indeed, if a certain level of spatial skill is required in order to employ GIS to accomplish class tasks successfully, then those students for whom this is lacking are likely to experience difficulties using the software for its intended purpose, and experience frustration associated with this. Furthermore, if this is the case, then it adds credence to the conclusion of Miller, Keller and Yore (2005) that it is a "luxury … to worry about strengthening digital geographic information literacy when the curriculum already struggles to find sufficient emphasis for basic geographical literacy and for fundamental concepts and abilities of geographic information handling" (p. 256).

Notwithstanding the above, the findings also clearly reveal the existence of some evidence of value in using GIS. It is apparent from the outcome space that there further exists the experience of the benefits of GIS as exceeding the difficulties and associated frustrations that all students, to a greater or lesser extent, experienced. Indeed, given this apparent dichotomy between student experiences, it is perhaps pertinent to consider the extent to which GIS constitute an equitable element of the Senior Geography curriculum.

Motivation

For most participants, using GIS was associated with increased motivation. Although this was due largely to effects of GIS on the curriculum with which students were meant to be engaged, it also represented other benefits that arose from the contexts in which it was used.

The link between class and life afforded by using GIS emerged repeatedly from the findings. For most students, using GIS was somehow associated with inquiring into and addressing local problems, which Klein (1995) sees as essential for students to develop empowerment. By studying areas with which students were personally associated, using GIS became a vehicle with which students could engage their geographical skills "associated with logical and critical thinking" in a context of immediate relevance (Cox, 1997, p. 50). That students saw the tasks that they were required to undertake with GIS as "both relevant and current" suggests their awareness of "the practical relevance of the subject to everyday living and problem solving" (Ballantyne, 1996, p. 180).

With respect to the findings, another of Ballantyne's (1996) suggestions holds true, where students experienced using GIS as an attractive alternative to the in-class activities otherwise required of them. This especially included the proposition of a decrease in the amount of writing undertaken in class when using GIS (p. 180), and the improved physical environments associated with using GIS in an air-conditioned room or as a part of fieldwork beyond the school gate.

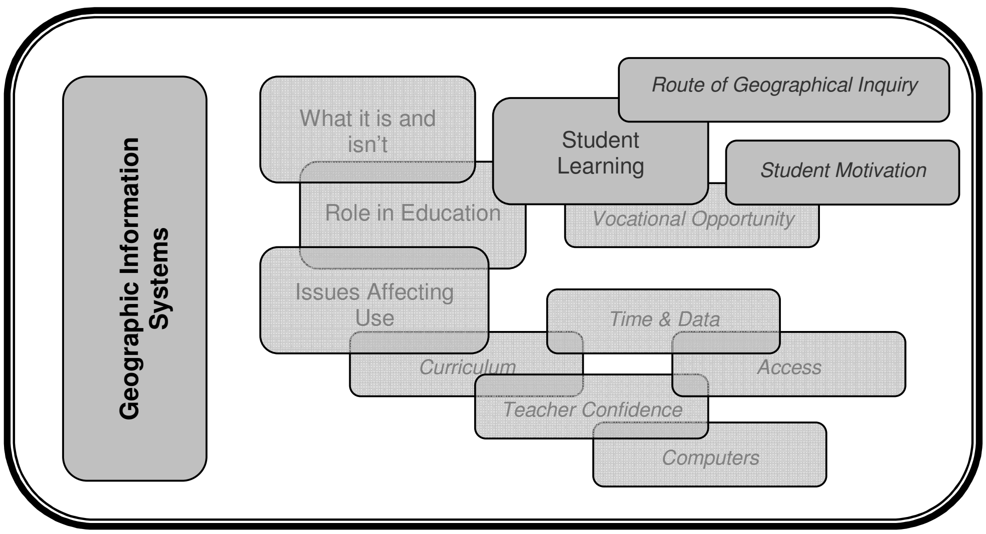
Fieldwork

Additionally motivating to students is their conception of the integrating function of GIS. This was especially evident during fieldwork, when students used GIS to make links between phenomena previously studied in class, and phenomena being observed *in situ*. It appears that the combination of group work, first hand experience of the transferability of concepts introduced in class, and the active nature of fieldwork appealed to students. While these three aspects of fieldwork can exist without GIS, because participants in the present study experienced GIS as an integral part of the fieldwork, they also experienced these three aspects as requiring not just the observation and collection of data, but using GIS to handle those data.

Whereas Atkin (2003) claims that fieldwork is an effective way to arrest student apathy in geography, the lived experiences of students using GIS as a part of fieldwork reveals that while its inclusion appears to have a motivating influence, this is not universally experienced. Although there exists some evidence that fieldwork stimulates students' curiosity, there also exists some evidence that the maps involved in GIS-based fieldwork pose difficulties for students. Given the general agreement that constructing and using maps is one of the most important features of worthwhile fieldwork, the difficulties and frustrations experienced by students trying to use GIS to do this made more difficult the task of mapping a local landscape while functioning in that landscape. Because of this, there exists some evidence that using GIS as a part of fieldwork eroded at least some of the widely asserted benefits of doing fieldwork.

GIS and Student Learning

The route of geographical inquiry and student motivation



With respect to student learning, the findings offer some contribution to what has largely been speculation about the role of GIS. Since GIS have been incorporated as a part of Senior Geography, it is not surprising that many of these contributions echo those already discussed in this Chapter with respect to geography education in general. Despite the risk of some duplication, it is appropriate given the nature of this study's three foci (geography education, GIS, questions remaining) now to consider the specific implications of the findings for the role of GIS in student learning within the geography curriculum.

Following my initial experiences of teaching with GIS as part of Senior Geography, in 1998 I published an article entitled *GIS in the secondary school: some possible outcomes* (West, 1998a). Although almost a decade old, the validity of many of its claims still remains untested and ill-clarified. In such a climate of uncertainty, educators – including myself - are thus making decisions about whether and how they will use GIS in what is a virtual vacuum of data about its potential and actual influence on student learning.

A fundamental reason for the use of GIS in Senior Geography is its capacity to unite large volumes of non-sequentially related data (Fitzpatrick, 2001; West, 1998a*)*. Because of this capacity, GIS readily constitutes an integrative tool that can bridge traditionally discrete subject areas (Baker, 2005), and thus present the opportunity to examine the spatial dimension of a range of multidisciplinary issues. Indeed, as alluded to earlier, it is this aspect of GIS that essentially constitutes its greatest potential to augment students' studies of geography.

However, if we accept the assertion by Gregg *et al.* (1997) that the way information is taught influences how that information becomes available for subsequent thinking, then it is important to consider the way that GIS and its spatial elements are taught to students. The findings suggest that despite student experience of GIS involving a substantial emphasis on spatial elements, especially location, for many students this did not appear to translate into an understanding of the spatial bases of those data. Rather, the Conception One experience that GIS was the maps that they saw, and/or was simply a source of maps, suggests that these students had not adequately configured the data represented in those maps in such a way that would support their subsequent analyses, evaluation and syntheses.

By way of corollary, however, this could also lead to the proposition that if the effective use of GIS requires students to engage in efficient data configuration and higher level spatial thinking, then using GIS may also be implicated in the further development of those (more efficient) processes. In this way, for students who possess an understanding of the spatial element of mapped data, using GIS may offer an opportunity to enhance their capacity to reason both in and with geography.

Indeed, the belief that GIS was personally relevant (Conception 5) and that it enhanced their studies in and beyond Senior Geography (Conception 6) has implications for the present discussion. This is because the spatial insight needed to reason with geography requires what Macaulay (1994) described over a decade ago as “the frequent use of higher-level thinking skills” (p. 23). Since higher level thinking requires configuration of information such that each datum is ascribed some meaning by its user, it becomes imperative that tasks using GIS are presented so that their constituent data can be coded in several ways, and so that they meet recommendations for learning preferred by Biggs and Moore (1993).

In geography, this coding commonly involves data being prioritised and placed into recognisable groupings, such as with a legend on a map. Hence, to be able to code data in several ways means that a student must first recognise that they can be grouped in several ways. While the findings did not explicitly reveal the extent to which students did do this, Conception Two (Mapping) and student references to KGIs, such as distribution and patterns, do indicate that it was a component of their GIS experience. Hence, arising from this emerges the possibility that students’ experiences of the personal relevance of GIS (Conception 5) and the improved nature of geography (Conception 6) may be somehow associated with their using GIS as a tool with which they could “process the vast quantities of information available, and to be able to build personal geographies in place and space” (Robertson, 2003, p. 21).

However, two aspects of the findings imply that, for many students, this did not occur. First, the majority of student references to spatial thinking were to lower order KGIs. Second, many students experienced a critical misunderstanding about GIS as a tool to process, rather than to simply present, spatially referenced information. For these students, understanding the *what?* and *where?* of data was sufficiently problematic. Further use of GIS thus presented both difficulty and frustration. Quite simply, these students were unable to build personal geographies because they did not sufficiently understand the building blocks with which to build them.

Interestingly, also emerging from the findings is the idea that when it comes to learning about these building blocks, it may perhaps be better to complete tasks without GIS. By extension, students who experienced what may be considered success when using GIS were those most likely to believe that they think more *about* data when constructing maps and manipulating mapped data by hand, but that they think more *with* those data when using GIS.

What this indicates is that not all students are capable of engaging with GIS tasks at the same level. In this regard, the potential for task differentiation has also been identified as a reason for using GIS in secondary education. While it is possible that those students who experienced difficulty with GIS may also have experienced difficulty in other aspects of their geography education, it does indicate some merit in clarifying for students of different ability whether what they are meant to be doing with GIS is intended for them learn about it, or learn with it.

In this respect, the teaching that occurs with GIS is important. Very clear from the findings is that students experience success with GIS only through some reference to their teachers' pre-determined notions of correct or otherwise. Perhaps interestingly, this was the experience for all students, regardless of their other experiences of GIS. It was just that students who possessed an understanding of the data themselves were more able and/or more likely to undertake the correct steps with GIS to reach this result; their use of GIS was thus influenced by their awareness of the data and the need to progress through a logical sequence of ordering and organising these data. For other, less successful, students, their attempts to undertake the correct steps to reach this result was influenced by their awareness that a particular sequence of steps should lead to the correct result, regardless of the data involved.

This is not isolated to students. Indeed, Fitzpatrick (2001) recalled similar experiences among teachers whom he trained in the use of GIS; those who are motivated by the delivery of knowledge are, when using GIS, most likely to emphasise the avoidance of data and IT-issues, rather than emphasising the pursuit of inquiry and data analyses. Perhaps this goes some way to explaining a common experience for students in this study: the desire to explore with GIS in a more independent manner. Indeed, to do so was seen by many as a way to increase their skills in its use, regardless of the difficulties and frustrations that they had already experienced, including those difficulties and frustrations related to data and IT-issues. For these participants, being free to explore its applications in a less prescriptive context was viewed as improving their ability to use GIS for its intended Senior Geography applications.

That students experienced such a desire indicates exposure of students to a dichotomy of how GIS was used. Teachers were invariably prescriptive in their use of GIS. Time was usually limited. Tasks were mostly linked to assessment. This created a context in which students needed to rather rapidly master the basic software procedures to allow rudimentary manipulation of spatial data while concurrently engaging with tasks that were designed to assess their analytical capabilities. Given this, it is perhaps unsurprising that from the findings emerges a broad experience of GIS as frustrating and beyond school needs.

Perhaps by being permitted to explore patterns of data with GIS more freely, students would be at liberty to make what Alexander (2006) describes as meaningful choices within tasks. Following the ideas of ESRI (1995), Fitzpatrick (2001) and Kerski (2001), employing the role of facilitator rather than deliverer of knowledge may not only improve teaching about and with GIS, it may also promote greater student motivation. To achieve this, however, requires teachers using GIS to relinquish some of the control that they traditionally hold over their classrooms (Richhardt, 2006).

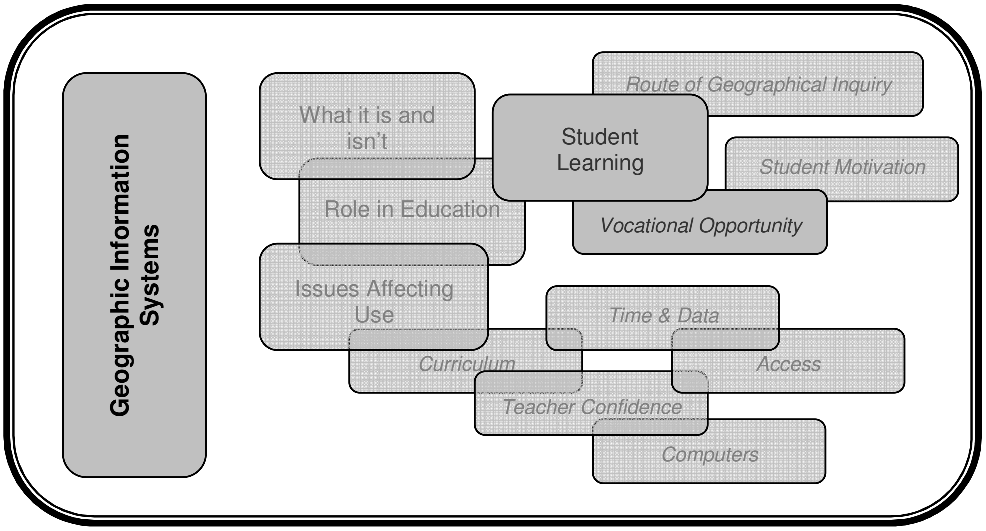
Of course, it is also important to bear in mind that improved student empowerment arising from the shift in locus of control from teacher to student will, no doubt, elicit varied consequences. Just by following Fitzpatrick's (2001, p. 87) recommendation to establish for students "a visible goal, and then stand back" will not necessarily lead to less difficulty and frustration while using GIS.

Rather, it is likely to enable - and, arguably, demand - a greater degree of differentiation. Students who require more learning *about* GIS would be able to consolidate their mastery of the basic software procedures, and students who possess adequate spatial awareness would be able to explore this more freely while learning *with* GIS. To do so might go some way to reduce the pervasiveness of Conceptions Three and Four. In any case, what this discussion has revealed is the need for greater balance between teaching about and teaching with GIS.

Such an approach resonates well with the findings of West's (2003b) attitudinal survey of students who had used GIS, where the improved motivation following use of GIS was deemed due to a combination of students developing higher level thinking skills while exploring issues of personal significance, and within a context of *an appropriate level of cognitive demand* (emphasis added).

Clearly then, there is a link between the development of higher-level thinking skills and the finding that students experienced GIS as offering a better geography (Conception 6). Also clear is the link between exploring issues of personal significance and the Finding that students experienced GIS as offering improved relevance within and beyond Senior Geography (Conception 5). What also appears clear, by implication, is that there exists some evidence that the provision of an appropriate level of cognitive demand enables the obstacles presented in Conceptions Three and Four to be transcended to enable experiences of Conceptions Five and Six. *Ipso facto* and also by implication, there exists some evidence that GIS is experienced at such an inappropriate level of cognitive demand that the obstacles presented in Conceptions Three and Four are insurmountable. This reveals the existence of conceptions of GIS that are experienced without the students first establishing a sound understanding of GIS' basic building blocks: data. Whether this was because their pre-existing spatial understandings were somehow lacking for the GIS tasks, or whether it was because the tasks themselves were somehow lacking remains unknown.

Vocational opportunity



With respect to vocational opportunities within the spatial sciences, in an email communication on 10 May 2007, Associate Professor Bert Veenendaal, Head of Department of Spatial Sciences at Curtin University of Technology indicated his view that the current strong demand for skilled people is expected to continue. However, simply being skilled in the use of GIS is not sufficient (Gewin, 2004). Rather, it is important that potential employees possess "a deep understanding of underlying geographical concepts" (p. 377).

At first glance, it would appear that the inclusion of GIS in Senior Geography would provide some small steps toward the development of both GIS skills and conceptual understandings. After all, in Senior Geography, the use of GIS is invariably undertaken as an integral component of a larger conceptual exploration of spatial processes.

Indeed, the findings indicate students do experience this link between their studies with GIS and their other studies of regional and/or global processes (Conception 5), with many students also experiencing what they see as a deeper understanding and insight into both local areas and global processes (Conception 6).

However, despite students being explicitly aware of a range of vocational opportunities associated with GIS, there are some implications of the findings that may indicate the use of GIS in Senior Geography may serve to stymie the progression of students from school into the spatial science industry. If we can assume that students' post-school engagement with GIS will depend, at least in part, on their experiences of it while at school, then it is important to consider those experiences.

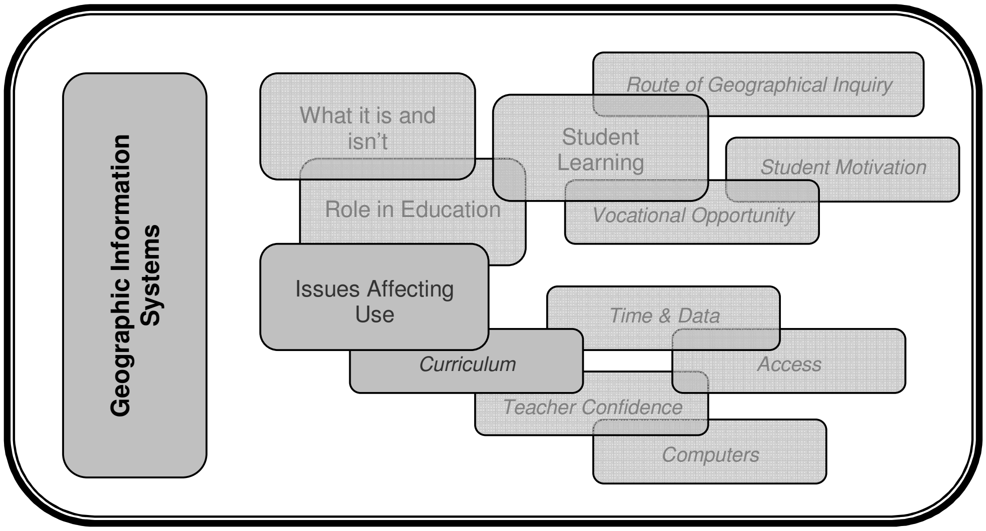
For example, for the many students who did not overwhelmingly experience GIS as relevant and beneficial, for whom the configuration of data was rather alien, using GIS effectively was a largely overwhelming possibility. Indeed, it was mostly these students who experienced GIS as being a professional tool that exceeded school need. For these students, GIS was too hard, with far too many ways of doing far more than they needed it to do in order to replicate what the teacher required them to. When we consider this, it is not surprising that an associated structural element of Conception Three was that GIS was a poor use of time. Indeed, it is likely that these experiences were the catalyst for two student suggestions. First, if GIS were to be used at school, then a simpler version would be preferred. Second, being introduced to it prior to entering Senior Geography would more likely enable students to gain the mastery needed to support learning with GIS. For students, both of these options were considered to be essential if teachers wanted students to succeed while using GIS.

Hence, not only does a failure to master an understanding of the basic elements of GIS' data handling functions limit students' use of GIS, it may also hinder their future engagement with it. Indeed, it is also possible that the time spent using it in class may be used better for the development in students of greater understandings of spatial concepts, so that subsequent exposure to GIS will be more likely to involve students experiencing conceptions such as those revealed in Conceptions 5 and 6.

Of course, it is not just what happens within the classroom that influences how GIS is used and students' experiences of it. It is to the implications of the findings for understanding the issues affecting the use of GIS that our attention now turns.

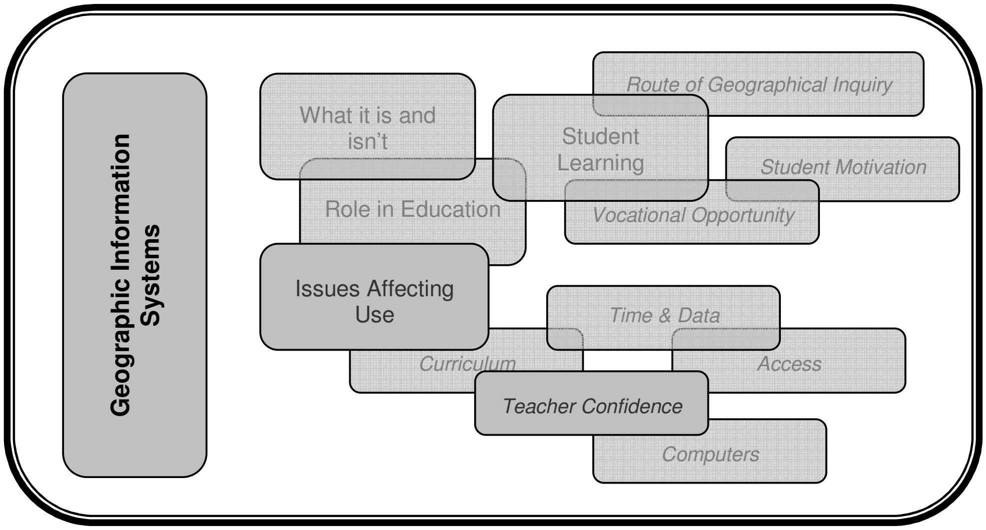
Issues Affecting the Use of GIS

Curriculum issues



The capacity for GIS to provide opportunities otherwise unavailable within the geography classroom was clearly obvious to students, who lauded this potential. However, the extent to which this could occur was limited by other curriculum issues. The tension between GIS' potential applications to Senior Geography and the syllabus requirements of Senior Geography was experienced indirectly by students. This occurred through their realisation that what they were doing with GIS was not being done by all students who study Senior Geography, leading them to question its necessity, and through their realisation that what they were doing could only be assessed to a limited extent. With regards this latter idea, students experienced some discord between the belief that using GIS would improve their assessment items through improved presentation, and the belief that using GIS made it more difficult to discern the actual geography that the students themselves had undertaken from the geography that the software had done for them. Students were further aware that GIS are not used as much as they could be, and explained this with reference to their belief that Senior Geography encompassed many elements, of which GIS were only one.

Teacher Confidence issues

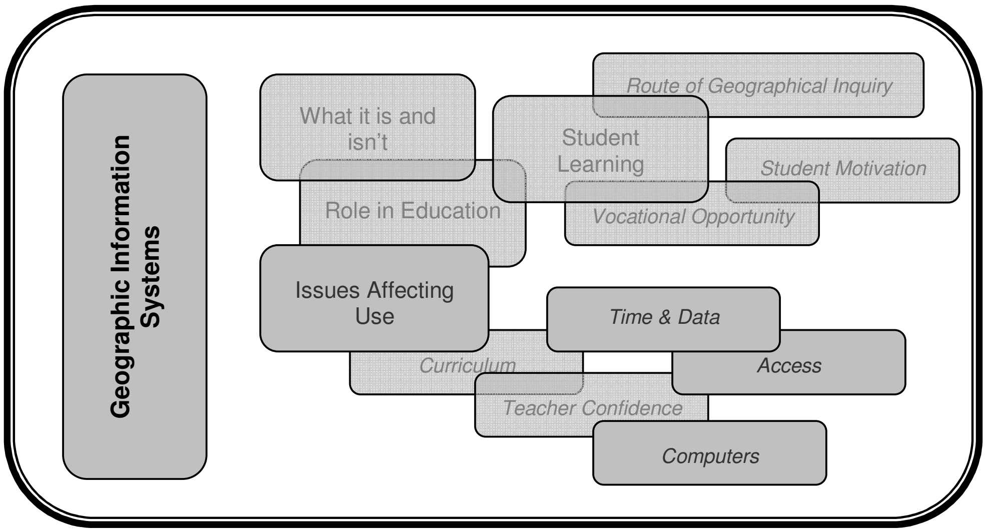


Teacher confidence with using GIS in an educational setting was an issue that was clearly evident to students, who made frequent references to the manner in which they were taught both about and with GIS. While students recognised the apparent enthusiasm of their teachers for GIS to be used in their lessons, students found the methods of instruction to be somewhat problematic. In this regard, students' experiences aligned with what Chalmer (2006) described as the social acceptance of ICTs not being matched with the education that promoted its use.

The way that GIS were used within lessons suggested to students that teachers were, perhaps, less experienced in using GIS as an educational tool than in other aspects of their teaching. In turn, this influenced both the teaching methods and the student experiences of its effectiveness as a tool *about* which they were to learn, and *with* which they were to learn. Much of their frustration with GIS revolved around how students were being taught. Despite the finding of Rake *et al.* (2006) that constructivist teaching methods were closely aligned to teacher ICT use, participants in the present study more commonly experienced transmission teaching methods, with instructions delivered in highly prescriptive verbal and/or printed forms. This level of teacher-centredness within the GIS classroom was compounded by student perception that teachers, despite their laudable enthusiasm for the technology's use, lacked the broad experience in its use that may enable more dynamic approaches to its use by and with students.

Related to this is that, although the multiplicity of data manipulating applications created strong opportunities for collaboration among students, this was usually unintended by the teacher. Indeed, and somewhat paradoxically, collaboration was usually limited to students compensating for what they saw as inadequate instruction; assisting one another to proceed through the teacher's prescribed steps.

Time, data, computer and access issues



As with teacher confidence, the constraints of time were also experienced by students through the manner in which GIS lessons were conducted, emphasising pre-scripted steps to achieve a common goal. Also, students experienced concern that what they were doing with GIS and what the Senior Geography syllabus required them to be doing may not have been aligned. This adds some credibility to the claims of Jenner (2006), McInerney and Shepherd (2006) and Meaney (2006) that it is not just teacher skill in using GIS that takes time to develop, but also it is the development of lessons using GIS that suit the curriculum that takes time.

These issues of time were also experienced by students, and in a number of forms. First, the time they did have was usually insufficient to enable them to confidently move through the prescribed activities. Second, the findings concur with Pun-Cheng and Kwan's (2001) conclusion that the lesson time needed to discuss, analyse and interpret data so that "the effective learning impact of GIS [could] be felt" (p. 91) was not built into the learning experiences, no doubt further compounding misunderstandings of GIS as a data processing tool. Third, students' experiences of GIS were influenced by the competition within schools for access to the necessary ICT resources.

Perhaps ironically, in many schools GIS' use was linked to assessment to increase likelihood of gaining access to the computer resources. This was obviously problematic for students who, because of GIS' role in assessment, were immediately aware of its importance. But, for these students, the need to complete the prescribed tasks in limited time had a major impact on their overall experiences of GIS, and for a single reason: it precluded them from gaining the wider understanding and skills associated with GIS in order to fully appreciate its potential significance within, and beyond, their geographical education.

While related to computer issues, the differential speeds of computers and networks was experienced as creating issues that affected the quality of GIS learning. Interestingly, this arose through both the high speed with which some schools' systems allowed GIS to process data faster than students could manage it, and the slow pace of some schools' systems, which created the opposite issue.

Emerging from student conceptions was that the nature of a school's computer arrangements influenced their experiences of GIS. This was specifically evident through Conception Three and Conception Four. Conception Three included references to issues related to processor speed, or lack thereof, and issues associated with using school networks to access and manage files, thus leading to the structural elements indicating GIS to be *a poor use of time* and *beyond school capabilities*. An extension of this conception was, for many students, Conception Four, Frustration.

Strengths of the Research

In addition to the contributions to education outlined previously, the study has also demonstrated the appropriateness of phenomenographic research approaches to investigate educational phenomena. Participation of students in the research involved them in actively contributing to decisions that will ultimately affect them and their peers. Anecdotally, numerous participants expressed some gratitude for the opportunity to consider their own experiences and to express their views about them, aligning this research with the widely held view that doing so is beneficial for researcher and student alike (Levin, 1991; Nagel, 2002; Ruddick, Day & Wallace, 1997).

The collection of very rich data through synergetic focus group interviews ensures validity of the data collection process since the depth and breadth of the discussion was led by students and not the researcher. Similarly, the emergence of six distinct Categories of Description, with their constituent referential and structural elements, and their cogent Outcome Space reflected the suitability of the data analysis process outlined in Chapter Three.

Finally, following Cope's (2002) recommendation, the findings have been presented such that they allow informed scrutiny. Provision for this includes the broad range of student references drawn from all interviews that were included within Chapters Four and Five.

Beyond the stated objectives of this study, undertaking this research has also afforded the researcher many benefits, including, but not limited to enhanced and expanded understanding of: educational theory and practice; research methods and their role within education; the place of teacher as researcher; and, perhaps more significantly, himself.

Limitations of the Research

Despite Chapter Three presenting a full account of the data collection and analysis procedures, further confidence in the study and its findings requires a reflection on six possible limitations.

1. Representativeness of the research sample

The use of a purposive sample presents some inherent limitations to the transferability of the findings. However, these issues were largely mitigated through the provision of rich descriptive data about the context in which the students had experienced GIS and the context in which the data were collected, in Chapter Three, and the manner in which the findings were presented (Chapter Four) and discussed (Chapter Five) to allow informed scrutiny.

2. Representativeness of participants

Despite all students from the target classes being invited to participate, not all did so. The reasons related to absence and, for one class, personal choice to work on assessment related tasks instead.

Participants were drawn from four schools. While additional schools were invited to participate, not all chose to do so, and some were unable to participate due to scheduling issues and some were unable to participate due to internal matters.

While it is possible that these absent and non-participating students may have made some contributions to group discussion, the size of the sample and the rich data that were collected from them are expected to mitigate any effects arising from their absence.

3. Representativeness of student conceptions through time

The conceptions captured through the findings represent the collective experiences of a particular group of students in time. It is not reasonable to assume that these will remain static. It was beyond the scope of this study, however, to entertain such an aim, which has been referred for future research.

4. Size of the sample

The sample size does not include all Senior Geography students in Queensland who have experienced GIS as part of their studies. However, within the scope of the present investigation, it is deemed sufficient since its goal was not to identify universal laws, but to understand the nature of these individuals' experiences. Furthermore, this study included 109 participants from 11 interviews, in comparison to the 15 to 30 participants that Franz (1994) and Trigwell (2000) suggest as ideal.

5. Circumstances surrounding data collection

Data collection times were largely influenced by the schools themselves, with some interviews scheduled immediately following use of GIS, and with others scheduled on the final day of Grade 12. It is expected that these variations and the responses from individual participants may lead to the recount of varied experiences based on such circumstances. The manner in which GIS were used and the experience of individuals with its use varied across the sample size, which also influences the findings.

6. Researcher subjectivity

My interest in this research topic stems from a decade of experience using GIS within Senior Geography classrooms. I have been a staunch advocate for its continued use and have stated my views publicly in a range of fora. In these circumstances, my own personal bias and subjectivity need to be both recognised and addressed. On the basis of my own personal and professional experience with this topic, I followed Sandberg's (1995, p. 156) recommendation and maintained "interpretive awareness" through all phases of data collection and analysis, as clearly outlined in Chapter Three. Additionally, the thesis includes what Glesne (1999, p. 152) describes as "rich description" of those factors that may somehow limit the findings, thus enabling the study's conclusions to be established through the explicit documentation of all steps and procedures that were undertaken (Francis, 1993).

While the design was based upon an acceptance that conceptions are the construction of experiences by individuals within specific contexts, the discursive analysis inherent in the design employed did provide an outcome space which possesses some degree of generalisability to similar situations (Glesne, 1999; Marton, 1981a).

Directions for Future Research

Emerging from this study are opportunities to gather additional information to further improve the collective understanding of GIS' position with education.

1. The research investigated a purposive sample of Queensland Senior Geography students. Further understanding of student experiences of GIS would be offered by broadening this sample to include students:
    i. from other schools;
    ii. from other grades and statutory authorities, including internationally;
    iii. who have withdrawn from Senior Geography after using GIS;
    iv. who have elected to, or otherwise experienced, GIS in a post-school context; and
    v. who experienced GIS as part of their pre-Senior studies but did not elect to study Senior Geography.

2. The research comprised a phenomenographic approach to capture student conceptions of GIS. Further understanding would likely emerge from using other qualitative and quantitative instruments to augment the data collected herein. Examples include pre- and post-attitudinal surveys, participant observation, and inclusion of data related to individual student performance.

3. Commencement of a longitudinal study to investigate the development of spatial thinking skills in contexts that include and omit GIS would likely contribute to a better understanding of whether and to what extent using GIS aids in the development of, or relies upon, spatial thinking skills in its users.

4. Further research into the conceptions of GIS held by other groups would enable worthwhile comparisons to be made with students' conceptions, notably those of educators and educational administrators, as well as the industry professionals that encourage its use in schools.

Conclusion

Chapter One introduced the assertion of Blachford (1971) that "it is in the fullest development of the mind that geography seems to have a place in the curriculum" (p. 216). Chapter Two then argued that the inclusion of any subject within a school's curriculum should be justified through the elucidation of not only the body of knowledge with which it is concerned, but its potential for developing in students broader capabilities for participation in the world. From this, it becomes incumbent upon educators to identify best the manner by which this knowledge can be learned and these capabilities developed; to fully develop young minds requires due consideration of the methods employed to inculcate the myriad benefits of a geography education.

Chapter Two then introduced three foci for this investigation: Geography Education; Geographic Information Systems; and Questions Remaining. Emerging from the literature review was that geography and a geographical education are valuable, and for three specific reasons: they are concerned with a multidisciplinary body of knowledge of global significance; they emphasise a range of technical and problem-solving skills; and, they allow for its students to develop capabilities to actively participate in the world about which they are learning. Given that geography is a worthwhile inclusion within school curricula, attention needs to be paid to how it is taught and the tools that are used to do so. With this justification in mind, Chapter Two moved to consider those teaching practices that may support both teachers delivering and students pursuing such an education. Within this, particular attention was afforded to the potential role of GIS as a means of attaining those educational goals, about which little is known for sure.

A clear directive thus emerged. Namely, it is appropriate to identify research that may constitute a 'starting point' and lead to a clearer understanding not just of GIS' role within geography education, but also of appropriate directions for future investigations surrounding its inclusion. From this, a central phenomenon and research question for the present investigation emerged through considering published opinion about specific interactions between GIS and geography education:

> *What are the conceptions of geographic information systems (GIS) held by Senior Geography students?*

To explore this research question further, Chapter Three evaluated the epistemological and methodological bases of research and identified the phenomenographic approach as an appropriate research method. Participant and school characteristics were also delineated in Chapter Three.

Six qualitatively different ways in which participating students conceive of GIS were described in Chapter Four, as was an Outcome Space which offered a diagrammatic representation of how these six conceptions are interrelated. Awareness of these conceptions and their cogent outcome space gives rise to a clearer understanding of GIS' role within geography education.

These findings clearly contribute to the understanding of how GIS may be used to enable geography's goals to be realised. However, they cannot be assumed to constitute given educational outcomes for all students. For many students, their capacity to experience the above benefits was curtailed by only a limited understanding of spatially referenced data as the building blocks of GIS' functioning. Thus, the range of experiences of GIS also encompassed those which may exert a deleterious effect on student progress toward the stated educational goals. In this regard, some students' particular combinations of experiences of GIS precluded them from attaining some or all of the benefits embedded within the above eight items.

When the findings are placed within the context of the literature, they make clearer the potential role of GIS in geography education. Particularly evident is that the experiences of students vary rather substantially in terms of both academic and affective responses to using GIS. Whereas some students experience GIS as both personally meaningful and as improving Senior Geography curricula, others experience them as insurmountably difficult and impeding their attainment of the syllabus' goals. The key difference appears to be the extent of individual students' understandings of the building blocks of spatial awareness, the data. However, it remains as yet unknown whether successfully using GIS requires such an understanding, or whether successfully using GIS develops such an understanding.

The Queensland Senior Geography syllabus aims to prepare students to "explore, understand and evaluate the social and environmental dimensions of the world" (Queensland, 1999a, p. 2). For the geographer, the concept of place offers both meaning and the potential for understanding. Given the increasingly central role of geographic information systems beyond the classroom for the use and manipulation of such spatially-referenced information data, it is not surprising then that these same technologies are widely presumed to offer an avenue for students to attain educational goals such as the above. Evidently, this study has made some contributions to the questions that emerged from Chapter Two and, by revealing the qualitatively different ways in which students experience GIS, it has achieved its goal.

However, decisions regarding the extent to which such technologies are to be used should at all times emphasise the probable rather than merely the possible educational outcomes for students, and be based in evidence of their capacity to effectively promote student learning. This thesis has gone some way to distinguish between the probable and the possible. While GIS *can* aid in the development of spatial awareness and *can* support geography education, it is not always implicated in the *fullest* development of the mind.

It is without a doubt that spatial thinking and spatial technologies – such as GIS – can benefit society. It is without a doubt that geography education can harness the capabilities of GIS to develop in students the skills of spatial thinking. Finally, it is without a doubt that there emerges from this study one particular imperative: educators, geographical or otherwise, must ensure that while using GIS students grasp the basic level of organising spatially referenced information, so that they too possess the spatial awareness requisite to harnessing the benefits of their geographical education; for themselves, and for the societies of which they are part.

This study confirms the value both of a geography education and of GIS. More significantly, it reveals that the value of the one exists not in isolation from the other; just as GIS gives meaning to place, so too does geography give meaning to GIS. And yet despite this apparent union, GIS and geography education remain at an historic crossroads: a place from which their futures may either converge or from which they may diverge. Divorcing the one from the other will destine the benefits of neither from being experienced. By contrast, reaping the benefits of GIS will demand that the intellect of geography be harnessed and reaping the benefits of geography will demand that the technology of GIS be harnessed. Indeed, it will only be by converging the technological capacity of GIS with the intellectual abilities promoted by geography that students will be able to access, process and make sense of the spatial information that they will be managing and manipulating using GIS. It remains imperative, therefore, that educators harness the convergent nature of geography education and GIS, enabling not merely the full development of the mind, but the full development of the citizenry's capacity to exploit and further the processes of democracy.

Appendix A: QUT Ethical Clearance

Date: Fri, 24 Feb 2006 12:04:35 +1000
From: "Research Ethics" <ethicscontact@qut.edu.au>
Subject: Ethics Application Approval: 4256H
To: "Mr Bryan Andrew West" <ba.west@student.qut.edu.au>
Cc: "Mr David Wiseman" <d.wiseman@qut.edu.au>

Dear Mr Bryan West ,

Re: Concepts of geographic information systems held by senior geography students in Queensland

This email is to advise that your application 4256H has been considered and approved. Consequently, you are authorised to immediately commence your project, with the following proviso:

- Approvals from Education Queensland and School Principals, should be provided to this office as they become available.

The decision is subject to ratification at the next available committee meeting. You will only be contacted again in relation to this matter if the Committee raises any additional questions or concerns in regard to the clearance.

Please do not hesitate to contact me further if you have any queries regarding this matter.

Regards

David Wiseman
Research Ethics Officer

Appendix B: EQ Approval to Conduct Research

Queensland Government

Department of
Education and the Arts

4 April 2006

Mr Bryan West
34 Penelope Street
CORNUBIA PALMS QLD 4130

Dear Mr West

Thank you for your application seeking approval to conduct research titled *"Conceptions of geographic information systems held by senior geographic students in Queensland"* in Queensland State Schools. I wish to advise that your application has been approved.

This approval means that you can approach principals of the schools nominated in your application and invite them to participate in your research project. As detailed in the research guidelines:

- You need to obtain consent from the relevant principals before your research project can commence.
- Principals have the right to decline participation if they consider that the research will cause undue disruption to educational programs in their schools.
- Principals have the right to monitor any research activities conducted in their facilities and can withdraw their support at any time.

At the conclusion of your study, you are required to provide the Department of Education and the Arts with a summary of your research results and any published paper resulting from this study. A summary of your research findings should also be forwarded to participating principals.

Please note that this letter constitutes approval to invite principals to participate in the research project as outlined in your research application. This approval does not constitute support for the general and commercial use of an intervention or curriculum program, software program or other enterprise that you may be evaluating as part of your research.

Should you require further information on the research application process please feel free to contact Dr Heather Chipuer-O'Neill, Principal Policy Officer, Strategic Policy and Education Futures Division on (07) 3237 1286. Please quote the file number 550/27/448 in future correspondence.

Yours sincerely

Carol Markie-Dadds
Director
Research and Education Futures
Strategic Policy and Education Futures Division
Trim ref: 06/32577

Strategic Policy and Education Futures
Level 21 Education House
30 Mary Street Brisbane 4000
PO Box 15033 City East
Queensland 4002 Australia
Telephone +61 7 3405 5738
Facsimile +61 7 3237 1175
Website www.education.qld.gov.au
ABN 76 337 613 647

Appendix C: Letter to Education Queensland Principals

Bryan West

Address 1
Address 2

DATE

Title
Address 1
Address 2

Dear <INSERT PRINCIPAL'S NAME>

I am presently conducting doctoral studies through Queensland University of Technology. The title of this research is *Conceptions of Geographic Information Systems (GIS) held by Senior Geography students in Queensland*. The purpose of this investigation is to identify what students think about GIS, and through this to better inform decisions about the role of GIS within schools.

Your school is one of several that has been identified as providing an appropriate context in which data may be collected. I am writing, therefore, to request permission to conduct a study involving students enrolled in Senior Geography at your school. The study will involve two aspects:

1. Site visit, which would involve me familiarising myself with the educational context in which GIS is used at your school.
2. Interviews, which will be involve groups of approximately 6-8 students. Each interview will be audio taped and preceded by an introductory monologue to ensure common understanding between myself and interviewees. Each interview is expected to take between 30-45 minutes. The number of interviews undertaken in any one school will depend on the number of students wishing to participate.

It is anticipated that this study would be undertaken during Semester One of this year.

There are no perceived benefits or disadvantages to the students being involved in this study. Participation of students in this study is voluntary. The students may also discontinue participation at any time without comment or penalty.

Confidentiality of participants is assured. Student names will not be used during collection of data. No student will be identifiable from the written records of the research project, nor from any publications that may arise from the research. The collected data (audio recordings, transcripts, field notes) from the study will be available only for access by my principal supervisor and myself. These data may be accessed for the purposes of undertaking work in related areas, namely workshops, presentations and publications in educational and research journals. Following completion of the research project, the data will be used solely for presenting work in educational and research forums. Audio-tapes will be destroyed once the project is complete.

Initial findings from this research are expected to be available by the end of the year, with publication of these expected from mid-2007 onwards. Results will be supplied to you.

Application to Conduct Research in Education Queensland State Schools and Other Units has been lodged with the Senior Research Officer – Strategic Policy and Education Futures in Central Office, as per Education Queensland Guidelines. A copy of both the application and of the approval notice is appended. Also appended are the information/consent forms that will be provided to students, and a copy of my current teacher registration certificate.

Should you wish <INSERT SCHOOL NAME> to be included in this research, in the first instance I will require your written consent. Once this has been received, I will provide the form for students and their parents/guardians that outlines the proposed research and seeks their written consent. I will also provide a brief outline of the proposed research for inclusion in your communications with parents. It is anticipated that interviews would be undertaken during Terms One and Two of this year.

Should you wish to discuss this proposal, or raise concerns about its conduct, I may be contacted directly on telephone , or via ba.west@student.qut.edu.au. Alternatively, you may contact my supervisor, Associate Professor John Lidstone, on 0413 485 957, or via j.lidstone@qut.edu.au, or the University's Research Ethics Officer on 3864 2340, or ethicscontact@qut.edu.au.

I would be grateful if you would consider this application favourably.

Yours sincerely

Bryan West

Encl.
Application to Conduct Research In Education Queensland Schools
Notice of approval to conduct research in EQ schools
Parent/student information/consent form
Teacher registration certificate

Appendix D: Letter to independent school principals

Bryan West

Address 1
Address 2

DATE

Title
Address 1
Address 2

Dear <INSERT PRINCIPAL'S NAME>

I am presently conducting doctoral studies through Queensland University of Technology. The title of this research is *Conceptions of Geographic Information Systems (GIS) held by Senior Geography students in Queensland*. The purpose of this investigation is to identify what students think about GIS, and through this to better inform decisions about the role of GIS within schools.

Your school is one of several that has been identified as providing an appropriate context in which data may be collected. I am writing, therefore, to request permission to conduct a study involving students enrolled in Senior Geography at your school. The study will involve two aspects:

3. Site visit, which would involve me familiarising myself with the educational context in which GIS is used at your school.
4. Interviews, which will be involve groups of approximately 6-8 students. Each interview will be audio taped and preceded by an introductory monologue to ensure common understanding between myself and interviewees. Each interview is expected to take between 30-45 minutes. The number of interviews undertaken in any one school will depend on the number of students wishing to participate.

It is anticipated that this study would be undertaken during Semester One of this year.

There are no perceived benefits or disadvantages to the students being involved in this study. Participation of students in this study is voluntary. The students may also discontinue participation at any time without comment or penalty.

Confidentiality of participants is assured. Student names will not be used during collection of data. No student will be identifiable from the written records of the research project, nor from any publications that may arise from the research. The collected data (audio recordings, transcripts, field notes) from the study will be available only for access by my principal supervisor and myself. These data may be accessed for the purposes of undertaking work in related areas, namely workshops, presentations and publications in educational and research journals. Following completion of the research project, the data will be used solely for presenting work in educational and research forums. Audio-tapes will be destroyed once the project is complete.

Initial findings from this research are expected to be available by the end of the year, with publication of these expected from mid-2007 onwards. Results will be supplied to you.

Ethical approval for this research has been granted, in accordance with QUT guidelines. A copy of this advice is appended for your information, as is a copy of my current Teacher Registration Certificate. Also appended is the information/consent form that will be provided to students.

Should you wish <INSERT SCHOOL NAME> to be included in this research, in the first instance I will require written confirmation of your consent. Once this has been received, I will provide the form for students and their parents/guardians that outlines the proposed research and seeks their written consent. I will also provide a brief outline of the proposed research for inclusion in your communications with parents. It is anticipated that interviews would be undertaken during Terms One and Two of this year.

Should you wish to discuss this proposal, or raise concerns about its conduct, I may be contacted directly on telephone , or via ba.west@student.qut.edu.au. Alternatively, you may contact my supervisor, Associate Professor John Lidstone, on 0413 485 957, or via j.lidstone@qut.edu.au, or the University's Research Ethics Officer on 3864 2340, or ethicscontact@qut.edu.au.

I would be grateful if you would consider this application favourably.

Yours sincerely

Bryan West

Encl.
Notification of Ethical Approval
Teacher Registration Certificate
Parent/student information/consent form

Appendix E: Letter to participating teachers

Bryan West

Address 1
Address 2

DATE

Title
Address 1
Address 2

Dear <INSERT TEACHER'S NAME>

I am presently conducting doctoral studies through Queensland University of Technology. The title of this research is *Conceptions of Geographic Information Systems (GIS) held by Senior Geography students in Queensland*. The purpose of this investigation is to identify what students think about GIS, and through this to better inform decisions about the role of GIS within schools.

Your Principal, <INSERT PRINCIPAL'S NAME> has given approval for your school to participate, and has indicated that I should liaise directly with you to coordinate the project. I am writing, therefore, to advise of the study's requirements.

The study will involve students enrolled in Senior Geography at your school. The study will involve two aspects, which will ideally occur during the one visit:

5. Site visit, which would involve me familiarising myself with the educational context in which GIS is used at your school.
6. Interviews, which will be involve groups of approximately 6-8 students. Each interview will be audio taped and preceded by an introductory monologue to ensure common understanding between myself and interviewees. Each interview is expected to take between 30-45 minutes. The number of interviews undertaken in any one school will depend on the number of students wishing to participate.

It is anticipated that this study would be undertaken during the first four weeks of Term Two this year. The precise time will be negotiated with yourself.

There are a number of tasks that I need to complete. These are:

1. Provide information and consent forms to students who have experienced the use of GIS as part of their Senior Geography studies
2. Collect consent forms from students and advise me of the number of students
3. Organise participants into interview groups
4. Identify an appropriate venue in which the interviews may be conducted
5. Identify interview times that are suitable for your school and its participants
6. Meet with you for approximately 30 minutes to discuss the nature and extent of GIS' use as part of your school's Senior Geography curriculum.

I would be happy to discuss with you the most efficient way of undertaking these tasks.

There are no perceived benefits or disadvantages to the students being involved in this study. Participation of students in this study is voluntary. The students may also discontinue participation at any time without comment or penalty.

Confidentiality of participants and schools is assured. Student names will not be used during collection of data. No student will be identifiable from the written records of the research project, nor from any publications that may arise from the research. The collected data (audio recordings, transcripts, field notes) from the study will be available only for access by my principal supervisor and myself. These data will be stored with my supervisor at QUT Kelvin Grove and may be accessed solely for the purposes of undertaking work in related areas, namely workshops, presentations and publications in educational and research journals. Following completion of the research project, the data will be used solely for presenting work in educational and research forums. Audio-tapes, transcripts and field-notes will be destroyed once the project is complete.

Initial findings from this research are expected to be available by the end of the year, with publication of these expected from mid-2007 onwards. Results will be supplied to the school.

I have appended for your reference a copy of the Introductory Monologue, Interview Guidelines and Parent/Student Information/Consent Form.

I will contact you by telephone prior to the end of Term One to discuss this proposal, and to arrange your school's further involvement.

In the meantime, should you wish to discuss this proposal, or raise concerns about its conduct, I may be contacted directly on telephone 07 , or via ba.west@student.qut.edu.au. Alternatively, you may contact my supervisor, Associate Professor John Lidstone, on 0413 485 957, or via j.lidstone@qut.edu.au, or the University's Research Ethics Officer on 07 3864 2340, or ethicscontact@qut.edu.au.

I look forward to working with you further.

Yours sincerely

Bryan West

Encl.
Introductory Monologue
Interview Guidelines
Parent/student information/consent form

Appendix F: Interview Consent Form

Conceptions of Geographic Information Systems (GIS) held by Senior Geography students in Queensland.

Bryan West,

Description

This project is being undertaken as part of an PhD project for Bryan West.

The purpose of this project is to identify what students think about GIS, and through this to better inform decisions about the role of GIS within schools.

The research team requests your child's assistance in identifying what students think about GIS.

Participation

Your child's participation will involve a focus group that is expected to occupy approximately 30-45 minutes. This interview will occur at your child's school, and will involve your child discussing GIS in a group of about eight Senior Geography students. Each interview will be audio recorded.

The audio recordings will be transcribed and then retained until completion of the research project. During this time, they will be available only to the principal researcher and his university supervisors. Audiotapes will be destroyed once the project is complete.

Since the entire focus group interview is to be transcribed, it is not possible to participate in the project without being audio-recorded.

Expected Benefits

It is expected that the results of the interview will not benefit your child, but their involvement in the project will provide information that will inform future decisions about the use of GIS in Australian schools.

Risks

There are no additional risks associated with your child's participation in this project.

Confidentiality

All comments and responses are anonymous and will be treated confidentially. The names of individual persons will not be required in any of the responses.

Voluntary Participation

Your child's participation in this project is voluntary. If you do agree for your child to participate, he or she can withdraw from participation at any time during the study without comment or penalty. The decision to participate will in no way impact upon your child's current or future relationship with QUT.

Questions / further information

Please contact the research team if you require further information about the project, or to have any questions answered.

Concerns / complaints

Please contact the Research Ethics Officer on 3864 2340 or ethicscontact@qut.edu.au if you have any concerns or complaints about the ethical conduct of the project.

Conceptions of Geographic Information Systems (GIS) held by Senior Geography students in Queensland.

Bryan West

Statement of Parent/Guardian consent

By signing below, you are indicating that you:

- have read and understood the information sheet about this project;
- have had any questions answered to your satisfaction;
- understand that if you or your child have any additional questions you can contact the research team;
- understand that you or your child are free to withdraw at any time, without comment or penalty;
- understand that you or your child can contact the research team if there any questions about the project, or the Research Ethics Officer on 3864 2340 or ethicscontact@qut.edu.au if they have concerns about the ethical conduct of the project;
- understand that the project will include audio and/or video recording; and
- agree to your child's participation in the project.

Name ______________________________

Signature ______________________________

Date ____ / ____ / ____

Statement of Child consent

Your parent or guardian has given their permission for you to be involved in this research project. This form is to seek your agreement to be involved.

By signing below, you are indicating that you agree to participate in the project.

Name ______________________________

Signature ______________________________

Date ____ / ____ / ____

Appendix G: Introductory Monologue

Good morning/afternoon. I'd like firstly to thank you for being involved today.

Before we get to the topic, I would like to advise that I am tape recording this session so that I can transcribe it later. I will also take notes. I will then combine your conversations and the notes with those from other groups who are involved in my study. At no time will you be identified, either while I analyse the data, or publish the results. Your confidentiality is certain. There are no right or wrong answers. You will not be graded in the things that you say. I will not judge you for the things that you say. Standard courtesy, however, is required. If at any time you wish to stop participating, you may do so freely.

So, what is this about?

When I think about GIS, I see certain things. Because of my experiences, I have certain beliefs about it. I can define it, describe how it can be used, suggest ways that it affects what and how students learn, and argue about its role in Senior Geography.

But, as a teacher, I understand that students might have different beliefs about GIS. So, my aim is to find out what students who do Senior Geography think about GIS. You are all enrolled in Senior Geography. You have all used GIS as part of your Senior Geography studies. This means that you have had some experience of GIS.

I would like you to talk about your experiences of GIS.

Appendix H: Sample interview questions

The following questions may offer a guide to possible conversation topics

1. What does GIS stand for?
2. What does GIS do? Do you think that its name is appropriate for what it does?
3. How does GIS structure information about the world?
4. Is GIS hard or easy? What bits are hard, and what bits are easy?
5. What sorts of things do you do with GIS and how do these compare with other things you do in your Geography classes?
6. Is GIS just another computer program that you use at school?
7. Do you enjoy using GIS? If so, what is it that you enjoy about using GIS? If not, what is it that you find not enjoyable, and what would you prefer to be doing instead?
8. Does using GIS make doing Geography easier or harder?
9. Is using GIS the best way to use your class time?
10. What sorts of things make using GIS worthwhile?
11. Why do you think your teacher chooses to use GIS?
12. When you use GIS, do you think that you achieve the goals that your teacher intends?
13. Would you recommend that GIS be used by all students who study Geography?
14. Do you think that GIS could be used in other subjects?
15. How often do you use GIS, and for what types of things?
16. Would it be possible to do the things that you do with GIS without using computers?
17. Why is GIS used in Senior Geography?

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