Geographic Information Literacy in British Columbia's K-12 Education Curriculum

By

Jason Allen Miller
B.A., Simon Fraser University, 2000

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF ARTS

in the Department of Geography

We accept this thesis as conforming
to the required standard

[redacted]

Dr. C. Peter Keller, Supervisor (Department of Geography)

[redacted]

Dr. Eileen Van der Flier-Keller, Departmental Member (School of Earth and Ocean Sciences)

[redacted]

Dr. Larry Yore, Outside Member (Faculty of Education, Department of Curriculum and Instruction)

[redacted]

Dr. John O. Anderson, External Examiner (Department of Educational Psychology and Leadership Studies)

Supervisor: Dr. C. Peter Keller

ABSTRACT

Geographic information has benefited from the spread of information technologies. A wider audience has been exposed to geographic information. At this time there is an opportunity to develop an understanding of what users need to know about using geographic information. This understanding is termed geographic information literacy (GIL). Examining geographic information literacy through K-12 education provides an opportunity to investigate how students are introduced to geographic information and what they learn about it through the course of their K-12 education.

This thesis presents results from an online questionnaire that was used to gather the opinions of geographic information users on the topic of K-12 geographic information literacy. The results of the questionnaire illustrate that geographic information users consider traditional geographic information concepts and abilities as essential items for K-12 students. The results of the questionnaire led to a GIL content analysis of selected sections of the provincial curriculum. The results of the content analysis showed that traditional geographic information is covered within the current curriculum. Conversely, digital geographic information is not included in the province's current curriculum.

[redacted]

Dr. C. Peter Keller, Supervisor (Department of Geography)

[redacted]

Dr. Eileen Van der Flier-Keller, Departmental Member
(School [redacted]

[redacted]

Dr. Larry Yore, Outside Member
(Faculty of Education, Department of Curriculum and Instruction)

[redacted]

Dr. John O. Anderson, External Examiner (Department of Educational Psychology and Leadership Studies)

TABLES OF CONTENTS

TABLES

FIGURES

ACKNOWLEDGEMENTS

"I have no professional training. I gave my best, I have no regrets at all"

William Hung, American Idol Contestant

I would like to thank my supervisor Dr. Peter Keller for his supervision over the last two and half years. To borrow a hockey analogy, he allowed me to play myself into shape. I would also like to thank my committee members Dr. Eileen Van der Flier-Keller and Dr. Larry Yore. I am especially grateful to Dr. Yore for his help and patience with the numerous revisions of the thesis. The efforts of all three individuals have helped me to create an interesting document. I also would like to thank Dr. Ian ("the oracle") O'Connell for his help and advice through out this entire process.

I would also like to thank Dr. Olaf Niemann, the grad advisor when I started the graduate program, for his advice and for keeping the mood in the lab light. I would also like to thank Dr. Joe Parsons, from counseling services, for helping me to get through a difficult time. I would also like to thank the office staff of the geography department for their help and kindness through out this process. I am also extremely grateful to all of the individuals who took the time to complete my questionnaire. Also, I would like to thank Cheryl Murtland, Kristin Davel and Becky Davis, from St. Michaels University School, for their help with the organization and execution of the CAG teacher workshop.

The appropriate thing to say at this point would be that my research is my major accomplishment of the last two and half years, but how often do I say the appropriate thing. In truth, my major accomplishments are the friendships that I have made while in Victoria. I extremely grateful to Ian and Paula for their support and friendship. Thank-you for your hospitality, for putting up with me (especially Paula) and for listening. Thanks to Kristin for always being supportive and encouraging and for being there when I needed someone to talk to. Thanks to John for the countless pints and coffees we have enjoyed and for the numerous times we moved the line of decency and failed to keep it in the car.

Finally, I would like to thank my family for their love and support through out this process. Thanks to my mom and dad for their love and encouragement through out this process, and all of my education. You taught me to work hard and always do my best and I will always be grateful for that. I also would like to thank my brother Chris, my grandparents for their support through out this process. Thanks to Shirley for always being supportive and understanding of my educational endeavors. I would also like to thank Ken and Joan Anderson for always being supporting of me and this process. Thanks to Jennifer for your love and support through out the last four years. You have always been my strongest supporter through out this process and I will be forever grateful.

DEDICATION

To my family

Without your support this would not have been possible

INTRODUCTION

[the map is packed on top of the car on the way into New York]
"So you were planning on studying it later, academically or something?"

Jerry Palter from A Mighty Wind

1.1 Contextual Introduction

The idea of literacy is of the utmost importance when analyzing what is taught, or what should be taught about geography in schools. However, such an analysis is problematic since proposing a single definition of literacy is difficult. The array of definitions for science literacy illustrates the difficulty in defining disciplinary literacy (Clay, 1996; Hodson 2003; Norris and Phillips, 2003). The difficulties faced in defining literacy have generated important debates among academics; the value of these debates have been critical to the evolution of various disciplines. At a basic level, being literate means the ability to read and write (Jarolimek et al., 2003). In recent years, definitions of literacy have also evolved to include mastery of subject or disciplinary knowledge. Therefore, in its current usage, literacy refers to competency in language and knowledge of a discipline (Harris and Hodges, 1995). The result of these changes means disciplinary literacy now consists of; the abilities and habits of mind to construct understanding, ideas, unifying concepts and informed decisions, and communication strategies to inform other about ideas concepts and opinions (Ford et al., 1997).

Evolving definitions of literacy should not be examined independently of each other. The ability to read and write is crucial to disciplinary literacy (Norris and Phillips, 2003; Yore et al., 2002; Yore et al., 2003), yet, the issue of literacy in the language of a discipline is often overlooked when constructing a definition of subject literacy. An individual lacking basic literacy is severely limited in the depth of their disciplinary knowledge, learning and education (Norris and Phillips, 2003).

Norris and Phillips (2003) have incorporated both the ability to read and write and the mastery of disciplinary knowledge into their definition of science literacy. They refer to the ability to read and write scientific materials as the *fundamental* sense of science literacy, while being knowledgeable and educated in science as the *derived* sense. Included within the definition of the *fundamental* sense of science is the "comprehending, interpreting, analyzing and critiquing of texts" (Norris and Phillips, 2003: 229). Activities relating to the *fundamental* sense of science literacy are activities which are directly linked to the carrying out of science, but do not represent "manipulative activities and working with the natural that are so emblematic of science" (Norris and Phillips, 2003: 230). The *derived* sense of science literacy includes an understanding of the larger unifying concepts of science, including: procedures of science and the relationship among science, technology, society and environment (Yore et al., 2003).

Literacy definitions, both basic and contemporary, have wide reaching implications, especially for education (Ford et al., 1997). For example, many governments invest significant resources into educational programs for the purpose of developing a labour force possessing basic literacy (Mackenzie, 2000). As well, governments attempt to ensure these workers possess contemporary literacies, which are in line with the demands of the economy. Governments in countries that invest in literacy programs subscribe to a belief that development of the appropriate literacies will ensure economic stability (Didsbury, 1994; Hodson, 2003). At this time, the global economy is demanding workers with literacies relevant to an information-based economy (Didsbury, 1994). Numerous forms of literacy are relevant to a knowledge driven economy with some of the more prominent forms including: workplace, functional, computer, media, and information literacy (Harris and Hodges, 1995). To keep pace with changes, governments are consistently re-evaluating and reforming educational systems to ensure that all students are receiving appropriate literacies (Bianchi and Kelly, 2003; Ford et al., 1997; Hodson, 2003; Morris, 1996; Pullin 1994).

Among western nations, educational reforms involve the usage of a standards based approach to disciplinary literacy (Anderson and Helms, 2003; Yore et al., 2003). The collective educational standards outline a definition of disciplinary literacy, detailing the level of knowledge, skills and attitudes individuals need to achieve to be considered literate. These educational standards are designed to be in line with understandings of literacy specific to individual subject areas (Ford et al., 1997). As a result, definitions of subject literacy through the standards documents have a profound affect on curriculum and instructional practices (Ford et al., 1997; Kirst et al., 1997). For instance, Australia, Canada, New Zealand, the United Kingdom and the United States promote a standards based approach to science literacy. The standards outlined by each nation include abilities and habits of mind necessary to build an understanding of the big ideas in science (Yore et al., 2003; Bianchi and Kelly, 2003). Educational standards, in part, draw on existing research on science literacy developed by academics within these countries (Clay 1996; American Association for the Advancement of Science, 2003). Yet, the overall success of these reforms to achieve the necessary results is highly disputed (Anderson and Helms, 2001; Bianchi and Kelly, 2003; Hodson, 2003; Morris, 1996).

Debate about what constitutes geographic literacy has been underway for several years. Yet, it can be argued, the discourse among scientists concerning literacy is further developed than the discourse among geographers concerning geographic literacy. The numerous and varying definitions of science literacy collected by Norris and Phillips (2003) demonstrate the advance of nature of their discourse. Therefore, it is important for geographers to examine definitions of literacy advanced by other disciplines as they may inform these debates. However, it is not only geographers that are recognizing the necessity for geographic literacy; governments are also working on the topic. Surveys in United States and Canada have revealed a lack of geographic understanding among citizens, which in the United States has led to the development of national standards for geographic education (Gregg and Leinhardt, 1994; Stoltman et al., 1999). *Geography for Life: National Standards for Geography (1994)* is considered the benchmark for geographic education within the United States. The Geography for Life document synthesized existing debate concerning geographic literacy to develop standards for K-12 geography (Geography Education Standards Project, 1994) This thesis introduces the idea of geographic information literacy which is a specialized form of geographic literacy and information literacy, involving what a person needs to know to be literate of geographic information.

1.2 Geographic Information

Geographic information is defined as:

> *"Information about objects or phenomena that are associated with a location relative to the surface of the Earth. A special case of spatial information."*
>
> (Maguire et al., 1991:167)

Geographic information includes items such as maps, globes, diagrams, aerial photographs and satellite produced images.

Humans have always relied on geographic information to communicate discoveries and directions, or to register ownership (Sui and Goodchild, 2001). The educational system has recognized the importance of geographic information in our lives, and considerable attention has gone into teaching students how to understand traditional forms of geographic information at the K-12 level (Gregg and Lienhardt, 1994; Kirman, 1996). Traditionally, medium for communication of geographic information has been through paper based materials (Gregg and Lienhardt, 1994). However, today geographic information is packaged and delivered in many innovative ways beyond the traditional forms.

The digital revolution has seen the introduction of information technologies (IT) specializing in geographic information, which in turn increased the public profile of geographic information (Peterson, 1996; van Elzakker, 2001). The increase in public profile raises the question of what the public should know about geographic information in the information age. The geographic information user community has so far largely overlooked this question. Instead, the community's focus has been on technical innovations that make geographic information accessible to a wider audience. In this thesis it is argued that access to technical innovations surrounding geographic information implies that users of geographic information require a new geographic information literacy (GIL) that considers the what, why and how questions thus far overlooked by the geographic information community. GIL is the possession of concepts, abilities, and habits of mind, which allow individuals to properly use and understand geographic information in a digital world. Geographic information literacy encompasses three primary areas: traditional geographic information, digital geographic information and information literacy.

Building geographic information literacy at the K-12 level presents an opportunity to create a generation of citizens with a literacy of contemporary geographic information. Geographic information literacy is a strong complement to existing social studies and information technology curricula. It also draws on core subject areas such as mathematics and science.

1.3 Research Objectives

The objective of this thesis is to examine how the province of British Columbia handles geographic information literacy at the K-12 level. Geographic information experts and users will be consulted concerning which concepts, abilities and habits of mind constitute geographic literacy in a digital world. Upon completion of the consultation process, the existing curriculum will be reviewed for the presence of concepts, abilities and habits of mind relating to geographic information literacy. At the conclusion of the review, recommendations will be made as to where the province's curriculum needs to be revised to better represent the topic of contemporary geographic information literacy. Due to the exploratory nature of the research methods undertaken as part of this thesis, there are limitations. These limitations will be discussed in each of the relevant chapters.

1.4 Chapter Summaries

Following this introduction the chapters are organized as follows:

1.4.1 Chapter Two – Literature Review

Chapter Two summarizes how geographic information fits into the existing K-12 education curricula. The chapter begins by examining how society is adapting to digital information. Included is a review of the current state of digital technology at the K-12 level.

Chapter Two also provides a discussion of geographic information literacy, including a review of previous literature regarding geographic information at the K-12 level. A focus of this chapter is on the efforts of educators to implement geo-technologies (i.e. cartography, geographical information systems and remote sensing) at the K-12 level.

1.4.2 Chapter Three - Methodology

Chapter Three describes the methods used to collect the data for this thesis, including:

- an online questionnaire targeting the geographic information expert community,
- a content analysis of portions of British Columbia's K-12 curricula.

1.4.3 Chapter Four – Analysis of Online Questionnaire

The results of an online questionnaire are analyzed to determine what geographic information experts believe are the essential concepts, abilities and habits of mind that define geographic information literacy at the K-12 level.

1.4.4 Chapter Five - Content Analysis of the Curriculum

The results of the content analysis of selected portions of the current K-12 curricula are reported. Selected portions of the province's education curriculum are reviewed to assess how the curriculum discusses essential and important geographic information literacy concepts and abilities as expressed by geographic information users.

1.4.5 Chapter Six – Summary and Recommendations

This final chapter summarizes the research and points out areas for future research concerning geographic information literacy at the K-12 level. In addition, recommendations are made about improving geographic information literacy at the K-12 level.

2. LITERATURE REVIEW

2.1 Introduction

The onset of an information-based economy has brought with it an excess of digital information. Section 2.2 summarizes how the information age has increased the presence of information in society and outlines how the advent of the information-based economy has affected the K-12 education system. Discussed within 2.2 is the need for K-12 students to develop information literacy and the wider trend towards information literacy including an understanding of the knowledge necessary to utilize information and information technology. At present, definitions of information literacy are being adapted to reflect discipline specific requirements. As an example, information literacy is relevant to geography in an information-based economy.

Section 2.4 discusses the changing nature of geographic literacy in an information-based economy. Focus is on the changing role of geographic information in the context of geographic literacy. In particular, section 2.5 examines how the shift towards an information-based economy has led to the usage of digital geographic information. Section 2.6 summarizes a case for increased geographic information literacy that integrates the unique properties of geographic information with information literacy. Section 2.7 discuses both the need for geographic information literacy at the K-12 level as well as the various ways digital geographic information is currently being used and taught at the K-12 level. Section 2.8 discusses metadata as an example of a concept neglected in the discussion of digital geographic information at the K-12 level. Also discussed is the need for a dialogue among geographic information experts as to the essential knowledge and abilities concerning digital geographic information at the K-12 level. As this research is using British Columbia as a case study, Section 2.9 describes the state of geographic education in the province of British Columbia.

2.2 The Information Society and K-12

A characteristic of the information-based economy is an abundance of information. Breakthroughs in information processing, storage and transmission have enhanced the profile of information and information technologies (IT), and these breakthroughs have had social, cultural and economic ramifications (Gibbins, 1998; Webster, 1995). The Government of Canada (1997) notes the move towards an information-based economy has had the following ramifications :

- Distance is no longer a constraint to activities such as: economic development, social interaction, and learning;
- An increase in information availability. The ability to create, manipulate and share information and knowledge is becoming increasingly important. As more information is available, its lifespan however is diminished; and
- Knowledge is increasingly becoming available to everyone. Knowledge will be used to improve society's decision-making abilities.

The ideological shift towards an information based economy has focused attention on K-12 educators to provide students with IT knowledge (Pachler, 2001). Contemporary expectations are that individuals require information technology (IT) knowledge to compete in a global, information-based economy (Moll, 1997). However, demands for an increased IT presence in education come from groups ambivalent to the work of teachers (Couture, 1997). This creates difficulties as teachers and schools work to incorporate technology in the classroom, but struggle as technologies change at a rate faster than schools are able to accommodate (Liberman and Miller, 2000). The cost of integrating technology into the classroom is also a tremendous burden on the limited financial resources of the educational system. As an example, the United States spends 6.9 billion dollars a year on educational technology (Kleiman, 2000). Unfortunately the purchased technologies are soon outdated, yielding a limited return on the investment.

The drive to include new technology at the K-12 level is not new. New technologies periodically have gained the attention of the education system (Buckingham et al., 2001). The education system's attraction to new technology is built upon the idea that new technologies will *revolutionize* the delivery of educational materials. Radio and television, for instance, are examples of technologies that have gone through this process. In time, each technology has found its niche within the classroom (Cuban, 1986), although seldom have new technologies *revolutionized* education and schools.

Proponents of educational technologies believe IT applications provide students with a rich and interactive learning environment, engaging students in a self-rewarding learning experience (Hefzallah, 1999). Technology is touted as a time saver, providing educators with multiple alternatives to teaching the same information (LeCourt, 2001), while at the same time supporting both individual and group learners (Lawson et al., 1999). In response, critics of educational technology believe it is used either to simply supplement existing instruction, or to teach technological skills to satisfy the technology industry. LeCourt (2001) argues:

> *"Technology has been brought into the classroom as a value neutral tool to support the teaching of skills deemed important for personal certification".*
>
> (LeCourt, 2001: 85)

What is generally agreed is that technology cannot solve all educational problems, and that some educational problems simply cannot be solved with technology (Postman, 1995). There also appears to be general agreement that computing technology and information access are increasingly linked, and that instruction in computing is necessary to participate in today's world. In the rush to teach students how to access vast quantities of information, there is little mention of teaching students how to make sense of the information they receive (Froese-Germain, 1998).

With the presence of technology in the classroom, no longer are teachers the sole source of knowledge. With contemporary information technologies students can access information from a variety of sources (Lawson et al., 1999), allowing teachers more time to focus on the evaluation and critical selection of quality information. To that end, curricula need to ensure that students receive equal quantities of information literacy and computer literacy (Jones and Falanga, 2000).

2.3 Information Literacy

To adjust to the abundance of information available in an information-based economy, it is necessary to educate the public about the proper and efficient use of digital information (Ercegovac, 2003). The possession of this understanding is termed information literacy. The Association of College of Research Libraries (ACRL) defines information literacy as a:

"set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate and use effectively the needed information."

(ACRL, 2000:2)

The information literacy guidelines proposed by California State University encourages users to question the quality and source of information in addition to being cognizant of appropriate uses for the information (Dunn, 2002). In order to measure information literacy the ACRL has developed five information literacy standards summarized in Table 2.1.

Standard	Definition
One	The information literate student determines the nature and extent of the information needed.
Two	The information literate student accesses needed information effectively and efficiently.
Three	The information literate student evaluates information and its sources critically and incorporates selected information into his or her value system.
Four	The information literate student, individually or as a member of a group uses information effectively to accomplish a specific purpose.
Five	The information literate student understands many of the economic and social issues surrounding the use of information and accesses and uses information ethically and legally.

Table 2.1: ACRL Information Literacy Standards (American College and Research Libraries, 2000: 8)

The aim of information literacy is to provide knowledge beyond the repetitive learning of software specific hardware and software frequently associated with computer literacy (ACRL, 2002). Computer literacy skills are important as they allow users to access digital information, computer skills quickly become outdated as technologies change (Burniske, 2000). Moreover, computer skills used to access information do not necessarily equate to information literacy. For example, checking email is a frequently preformed computer task, but do these types of computer activities represent information literacy (Evans, 2002)? It is the combination of computer and information skills which allow a literate person to compete and prosper in an information-based economy (Dunn, 2002).

To further the development of information literacy in an information based economy, discussions about information literacy need to move outside of their traditional communities (i.e. librarians and academics) to include a broader audience (i.e. K-12 students and educators) (O'English, 2002). Part of broadening the audience for information literacy will involve applying it to specific disciplines. Adapting general information literacy definitions to suit a specific discipline's information requirements is not an entirely new idea. Scientists, for example, have adapted definitions of information literacy to emphasize the ability to access information of a scientific nature and to analyze it critically (Welborn and Kanar, 2000). The result is science information literacy. Welborn and Kanar (2000) outline three primary dimensions of science information literacy (Table 2.2). Overall, issues of literacy which are important to scientists in the information society are also important to geographers and geographic information.

Dimensions	Descriptions
Tool Literacy	The ability to use and understand information tools including computers, printers, and network applications.
Resource Literacy	The ability to understand the form, format, location and access methods of information resources. In the sciences this would include knowledge of specific indexes and abstracting services, and specific types of scientific publication formats, such as research articles, review articles, conference proceedings, technical reports, etc.
Social Structural Literacy	An understanding of how information is socially situated and produced [and how it] fits into the life of groups...such as universities, libraries, research communities

Table 2.2: Dimensions of Science Information Literacy (Welborn and Kanar, 2000)

2.4 Geographic Literacy

In an information based economy geographers are in demand. The interconnectedness of the modern world brings to light the practical need for geographic knowledge (Geography Education Standards Project, 1994). Geographers occupy a unique position in society as geography is located between the physical and social sciences (Mayhew, 1997). Additionally, geographers are adept at studying spatial distributions and spatial relationships and how they relate to people's interactions with their environments (Small et al., 1989). Numerous definitions of geographic literacy exist with most definitions centering on the interactions between humans and the earth.

Traditionally, geographic education has focused on building an encyclopedic knowledge about the earth. This method is referred to as the *capes and bays* style of geography (Holland, 1998). However, in the 1980's the *capes and bays* approach to teaching geography began to be questioned as American educators became concerned about the lack of geographic literacy in the United States. The educators' sudden interest in geographic literacy was driven by low secondary student enrollment in geography courses and poor results on public geographic knowledge surveys (Stoltman et al., 1999).

As a part of the more recent resurgence in geographic literacy there has been a move away from the traditional approach to teaching geography. A significant outcome of the renewed interest in geography was the development of the *Geography for Life: National Standards for Geography* out of the United States (Gregg and Lienhardt, 1994). The National Geography Standards were part of the *America 2000-National Education Act.* The Act outlined competency standards for students in subjects including: english, mathematics, sciences, foreign languages, arts, history, and geography (National Centre for Geographic Education, 2003). National standards for geography educators focus on an approach to geographic education centered around the interrelationships between the human and physical components of the earth (Geography Education Standards Project, 1994). The importance of geographic information to geographic literacy is exemplified by its prominent profile in these standards. Being able to understand and use geographic information is an essential component of geographic literacy (Gregg and Leinhardt, 1994).

The *Geography for Life* standards, in part, recognized the changing nature of geographic information in an information-based economy. However, since the publication of the original *Geography for Life* document much has changed in terms of how geographic information is accessed and used. At the time of the document's publication, the focus of geographers was on teaching students the tools and technology necessary to access and manipulate geographic information (Pickles, 1995). Now there has been a shift towards understanding the ramifications of technologies used to access geographic information, and to better understand digital geographic information (Chrisman, 1999).

2.5 Digital Geographic Information

The Internet has fundamentally changed how geographic information is handled and communicated, digital geographic information has become a feasible alternative to traditional sources of geographic information (Crampton, 1998; Peterson, 1996; van Elzakker, 2001). Digital geographic information satisfies the demands brought about by the move towards an information based economy, overcoming many of the weaknesses identified with the use of the paper map (Goodchild, 2000; Keller, 2001). The benefits of digital geographic information are many and include its ability to be:

- dynamic and flexible;
- easily transportable and can be linked to a variety of data sources; and
- a virtual medium, as storage of information is no longer an issue.

Recent improvements in digital technologies allow a broader range of society to access increasing amounts of geographic information. In theory, this increased access gives the public greater potential involvement in decisions which directly affect their lives (Karver et al., 2000), especially since sufficient access to geographic information is part of improving public participation in decision-making (O'Connell and Keller, 2002). As a result, an increasing number of private and public organizations now collect and distribute geographic information (Witham-Bednarz and Ludwig, 1997). An example of an organization collecting and distributing geographic information is Mapquest (www.mapquest.com). Mapquest has tapped into the growing interest in digital geographic information, allowing users to produce an estimated one and half million maps every day (Crampton, 1998).

Considering changes in the availability of digital geographic information, the criticism of geographic information and its related technologies (i.e. GIS) as an elitist tool may no longer be valid (Pickles, 1995). However, if geographic information is going to be used effectively by a broader audience, it is necessary to consider the information literacy of its users and their level of understanding about geographic information.

2.6 Towards Geographic Information Literacy (GIL)

Carter-Peoples and Krygier (2002) centre their definition of geographic information literacy on the definition of information literacy put forth by the Association of College of Research Libraries (ACRL). They argue:

> *"Geographic information literacy should be developed by integrating general ideas concerning information literacy into a geographic information specific curriculum. This fusion is how other subject areas are adjusting to the deluge of digital information"*
>
> (Carter Peoples and Krygier, 2002).

Figure 2.1 demonstrates how geographic information literacy fits within the broader context of literacy, bringing together the unique properties of geographic information, in either its traditional and digital form, with the theories applicable to all forms of information. GIL is achieved by introducing users to traditional and digital geographic information (DiBiase, 1996). Peterson (1997) believes exposure to digital geographic information to help improve a user's understanding of traditional geographic information. Aspects of information literacy, such as comprehending, evaluating, and analyzing information represent the *fundamental* sense of literacy as defined by Norris and Phillips (2003).

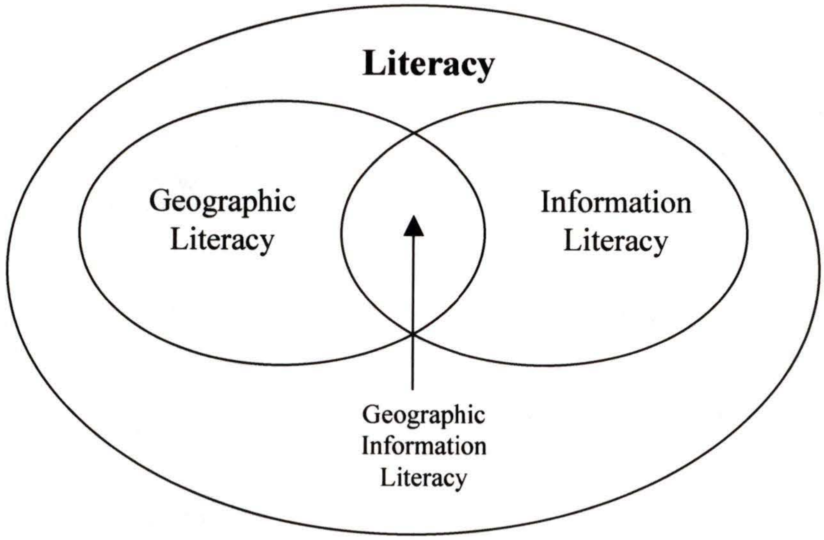


Figure 2.1: Contextual Diagram for Geographic Information Literacy

In an information-based economy, geographic information is open to greater abuse as inexperienced geographic information users access online warehouses of geographic information (Crampton, 1998). Geographic information technology has evolved to a point where a person with limited to moderate computer expertise can produce a map (Stiendorf, 2002). This results in maps that are poor quality, misleading and disregard geographic information rules and principles. Research conducted to assess users' knowledge of paper maps revealed that in 1996 as much as fifty percent of the United States population did not know how to use a map (Muehrcke, 1996). There exists no reason why this percentage should have improved in the last few years. Assuming such traditional geographic information illiteracy, there is no reason to assume improved literacy for digital geographic information.

Of central issue to this thesis is what knowledge constitutes geographic information literacy at various education levels. Obtaining greater understanding about geographic information is accomplished primarily through education, but knowledge is also acquired informally through everyday activities, such as: boating, skiing and orienteering (Alvermann 2002; Liben et al., 2002). Currently, an explicit, comprehensive framework defining what users of different skill or educational levels should know about geographic information does not exist.

The concepts and abilities necessary for the use of traditional geographic information have been established within the educational community and been taught for many generations (Chapin and Messick, 2002). These traditional geographic information concepts and abilities have a primary focus on: scale, projection, symbols, location, and distance (Grime, 1970; Obenhaus, 1990; Wiegand, 1998). Some of these traditional attributes are not applicable to digital geographic information. The National Center for Geographic Information Analysis (NCGIA) and their core curriculum in GI Science initiative (http://www.ncgia.ucsb.edu/giscc/) as well as the Geographers Craft Project (http://www.colorado.edu/geography/gcraft/content.html) are examples of attempts to define core concepts and abilities for digital geographic information content. The motivation for these projects was to improve the state of Geographical Information Systems (GIS) education in the United States by defining and offering a core curriculum of skills for users of GIS (Kemp and Goodchild, 1991).

2.7 Geographic Information Literacy through K-12 Education

The next logical step in the development of GIL is to take the concepts and abilities related to the use of geographic information and develop a definition valid of GIL that can be applied to K-12 education. Such a definition would not only articulate what GIL is, but also how GIL can be achieved. Kirman (1996) suggests that the public's problems with the usage of geographic information originate with how the subject is taught at the elementary and secondary grade levels. As an example of this point, elements of map making and interpretation are key parts of K-12 social studies curricula (Kadmon, 1988) and few classrooms are without the traditional materials for teaching geographic information (i.e. copies of paper atlases, wall maps and globes) (Keller et al., 1995; Hocking and Keller, 1993). Despite the availability of teaching materials, map skills are often taught for only a few weeks at the beginning of the school year, and in isolation from the other components of the social studies program (Chapin and Messick, 2002). It is important to pay attention to the instruction of geographic information at the elementary and secondary grades, as it is where students acquire and develop their understanding of abilities and habits of mind related to geographic information (Kirman, 1996). Research has demonstrated that adults did not benefit significantly from their K-12 experiences with geographic information (Chapin and Messick, 2002).

To address deficiencies in geographic information literacy at the K-12 level it is relevant to examine K-12 mathematics and science literacy programs that have been in place for several years (Hodson 2003; Morris, 1996; Yore et al., 2002). Their approach to improving literacy in these areas has been to define national standards in the subject area and to follow-up the standards by targeting the curriculum (Bybee, 1997). Curricula have changed over time to reflect new ideas of literacy in the literature and to provide educators with new alternatives to existing teaching methods. A plan to improve K-12 geographic information literacy should follow these examples.

Where digital technologies have taken hold in the classroom, the emphasis has been on using these technologies to improve geographic education (Fitzpatrick, 1993). Throughout the 1990's, there has been a move towards the introduction of digital geographic information within the K-12 education system as part of an overall plan to improve the quality of geographic education (Witham-Bednarz and Ludwig, 1997). Proponents of digital geographic information regard it as a fresh way of introducing geographic information to students (Witham-Bednarz and Ludwig, 1997; Fitzpatrick, 1993). It also corresponds with the educational objective of having technology play a greater role in the classroom (Audet and Paris, 1997).

Recommendations in *Geography for Life* (1994) from the United States and the *Canadian National Standards for Geography* (2001) mention the use of geo-technologies (i.e. geographical information systems (GIS), remote sensing, digital atlases and global positioning systems (GPS)) to improve geographic education (Canadian Council for Geographic Education, 2001; Geography Education Standards Project, 1994). However, recommendations lack specifics and do not provide learning outcomes and methods for using geo-technologies to improve geographic understanding. Consideration of these examples provides background on how these technologies can be being used at the K-12 level to partially enhance GIL.

2.7.1 Geographical Information Systems in K-12

The diffusion of GIS into the education system has been a popular topic amongst educators throughout the 1990's (Witham-Bednarz and Audet, 1999). The increasing level of interest is evident by the number of K-12 GIS meetings and staff development programs which have taken place throughout the decade (Witham-Bednarz and Audet, 1999; Witham-Bednarz and Ludwig, 1997). The likely catalyst for this increasing attention was the mention of GIS in the *Geography for Life: National Standards for Geography* (Geography Education Standards, 1994). GIS is seen as a powerful tool for exploring and analyzing information, allowing students to focus on inter-relationships present in their environment (Fitzpatrick, 1993). In addition, GIS facilitates constructivist learning, allowing students the freedom to guide their own learning process and construct their own understanding of these relationships (Keiper, 1999).

However, with all of its promise, GIS has yet to receive wide spread acceptance from the education community. Less than one percent of American schools currently use GIS in the classroom (Kerski, 2000), and generally, the profile of GIS is low among K-12 teachers. Donaldson (2001) surveyed teachers about their awareness of GIS and found that 89% of respondents reported being unaware of GIS until they were contacted for the survey. In terms of the stages of adoption for educational technologies, GIS is in the pre-awareness stage. The stages of technical adoption are included as Table 2.3.

Stage	Key Question
Pre-Awareness	
Stage 1: Awareness	What is GIS?
Stage 2: Understanding	How can I teach with GIS?
Stage 3: Guided Practice	How do I do GIS
Stage 4: Implementation	

Table 2.3: Four Stages in the Adoption of Educational Innovation (Witham-Bednarz and Ludwig, 1997; 127).

To improve the profile of GIS within the education system, GIS needs a greater exposure in teacher education and professional development programs. It is common for pre-service teachers to be taught to use technology, but it is rare for teachers to be taught about GIS (Witham-Bednarz and Audet, 1999). Traditionally, the pattern of GIS adoption has been for individual teachers to learn about GIS while on the job (Witham-Bednarz and Audet, 1999). These teachers were exposed to GIS through a combination of: (1) conference presentations, (2) personal contact with software vendors; and (3) professional journals. The barriers preventing the widespread adoption of GIS in K-12 education are not dissimilar from those associated with the adoption of other types of technology in the classroom (Donaldson, 2001). Teachers must deal with issues such as: ownership of up to date technology, and adequate professional development programs (Zhao et al., 2002).

In recent years, several barriers preventing the wide-scale adoption of GIS at the K-12 level have been overcome. Software providers are supplying schools with low cost software and the Internet provides teachers with access to geographic information on a variety of topics. The KANGIS website (www.kangis.org) is an example of a website where teachers can find material on GIS. However, issues such as a lack of GIS based curriculum materials and a shortage of teacher support networks have yet to be addressed (Meyer et al., 1998).

2.7.2 Remote Sensing and K-12

Teachers have long known the advantages of using aerial photographs to study geographic phenomena and remote sensing builds on these advantages. The advent of digital technologies has turned digitally remotely sensed information into an alternative source of geographic information for geographic educators (Kirman and Unsworth, 1992). Remote Sensing, when used to supplement the teaching of topics within geography curricula, can enhance existing materials and motivate students (Kirman and Nyitrai, 1998; Merry and Stockman, 2001). With its capacity to capture large areas of the earth in a single image, students are able to use remotely sensed data to study environmental issues (Kirman, 1997; Fitzpatrick, 1993). Yet, with all of its potential, remote sensing goes unnoticed by geography educators. Few teachers at elementary and secondary levels are aware of its educational capabilities (Kirman, 1997). Like geographic information systems, remote sensing has benefited from the creation of national standards for geographic education. Kirman and Busby (2000) argue that remote sensing satisfies ten of the eighteen standards mentioned in the *Geography for Life* document (Table 2.4).

The attention garnered from the *Geography for Life* document led to the creation of the *Pathways Project,* funded through the National Council of Geographic Education (NCGE). The projects goal is to improve geographic education through remote sensing.

The focus of the project is to support elementary and secondary teachers interested in bringing remote sensing into their classrooms (National Council of Geographic Education, 2003).

Standard No.	Description
1	How to use maps and other geographic representation, to acquire process and report information from a spatial perspective.
3	How to analyze the spatial organization of people, places and departments of the earth surface.
4	The physical and human characteristics of place.
7	The physical processes that shape the patterns of the earth surface.
8	The characteristics and spatial distribution of ecosystems on the earth's surface.
9	The characteristics, distribution, and migration of human populations on the earth's surface.
14	How human interactions modify the physical environment.
15	How physical systems affect human systems.
17	How to apply Geography to interpret the past.
18	How to apply Geography to interpret the present and plan for the future.

Table 2.4: Ten of the Eighteen Geography Standards Satisfied by Remote Sensing (Kirman and Busby, 2000: 135)

Often, it is assumed that remote sensing is too complex for students to understand; yet research has shown that students as early as grade three can work with satellite imagery such as Landsat or Radarsat (Kirman and Busby, 2000). *Project Omega,* at the University of Alberta's Faculty of Education, has extensively researched remote sensing curricula and instruction at the K-12 level (Kirman and Busby, 2000; Kirman, 1980). The focus of their work deals primarily with using Landsat satellite imagery to map land use in parts of Alberta. *Project Omega* recommends introducing remotely sensed information to students in grade six (Kirman and Nyitrai, 1998). This grade level coincides with a stage of cognitive development whereby children between the ages of seven and eleven develop their ability to connect the meaning of numbers and what they stand for (Kirman and Jackson, 1993; Kirman and Unsworth, 1992). This ability is considered to be critical when working with satellite imagery, as information is coded with numbers and stored as a raster. A raster is a technique for representing geographic information that divides space into a series of uniform shaped cells (DeMers, 1997). Introducing remote sensing at the elementary level puts in place a basic foundation which can be built upon at the secondary level (Kirman and Busby, 2000).

2.7.3 Digital Atlases and K-12

Traditionally, paper atlases are a staple of the K-12 classroom and libraries, and they typify much of the work done in K-12 Geography (Hocking and Keller, 1993); Keller et al., 1995) The educational value of the atlas is difficult to question, as schools have purchased atlases in large quantities and students enjoy using them (Wiegand, 1998). However, recent improvements in digital technologies have brought about a move towards digital atlas products (Linn, 1997). Digital atlas products are web-based or are stored on CD, and allow users to access data from a variety of sources. Digital atlases are not static, as information can be updated as needed (Moseley, 2001). Digital atlas technologies are a natural fit for teaching geography at the K-12 level because their non-linear organization and instantaneous random access capabilities allow students to explore geographic concepts (Pride, 1997). Digital atlases present students with a non-threatening learning environment where they are encouraged to explore presented information (Hefzallah, 1999). As a result, students are more active in the learning process utilizing digital information, compared to traditional paper based information.

To improve digital atlas usage amongst educators, teaching materials are also being packaged with the atlases. Providing teachers with educational materials is seen as one way of improving the usage of new technology (Hefzallah, 1999; Lawson et al., 1999; Witham-Bednarz and Ludwig, 1997). Teachers are more likely to use digital atlas products if they include pre-designed teaching materials which fit with existing curricula (Witham-Bednarz and Ludwig, 1997). Teachers can spend the time they saved designing teaching materials on familiarizing themselves with the technology.

Digital atlases do not require experts to produce maps. Students can create their own maps using software currently available in schools. For instance software such as KIDPICS allows students to create personal map portfolios. Allowing the student to act as cartographer and to experience geography in action, thereby illustrates one way to improve their geographic information knowledge (Linn, 1997; Mathews, 1986; Wiegand, 1998). By empowering students, it is possible to make them an active part of the learning process. If students are responsible for constructing maps, as opposed to only reading them, they are more likely to remember what they have learned about geographic information (Linn, 1997; Wiegand, 1998).

2.7.4 Global Positioning Systems (GPS) and K-12

In the past ten years Global Positioning Systems (GPS) have evolved from a specialized tool used by the military to a commercial device found in products ranging from automobiles to cellular telephones (Baker, 2001; Broda and Baxter, 2002). The global positioning system is a network of twenty-four active satellites which circulate the earth every twelve hours. When a GPS receiver obtains a signal from at least three satellites, the receiver triangulates a location on the earth's surface. With a fourth satellite, elevation can be determined. In recent years the cost of GPS receivers has dropped significantly, and receivers can now be purchased for approximately 100-150 dollars (Baker, 2001). The decreasing cost of GPS receivers make it possible for schools to purchase the technology (Flournay et. al, 2001; Wilke and Lambert, 1996).

Teaching with GPS helps to breakdown boundaries for teaching geography, as it can be used to teach basic mapping and navigation skills (Reichard, 2002). GPS receivers ease the use of geographic information by storing the information as digital co-ordinates, which can be integrated with GIS or remotely sensed imagery. By going out and doing the work themselves, students can understand geography as something more than names and places (Baker, 2001). The practical learning process helps students build their own spatial representation of the world and a more accurate image of the nature of geography.

GPS also blends geography with mathematics and science concepts. In the United States, geography meets the requirements for teaching mathematics and science using real world problems. Teaching with GPS provides the following interdisciplinary opportunities (Flournay et al., 2001):

- solve problems by applying knowledge from mathematics and science;
- use representations to interpret physical and social phenomena;
- use mathematics and geometry to process information from GPS receivers; and
- select and use appropriate statistical methods to analyze data.

The barriers to the implementation of GPS programs at the K-12 level are the same as with other technologies, such as GIS and remote sensing (Baker, 2001; Broda and Baxter, 2002). There is a lack of faculty members trained in the proper use of global positioning systems and the cost of equipment is also an issue. Few schools have the financial resources to purchase GPS receivers or to provide professional development. One way around the cost issue is to borrow equipment from local government agencies or universities (Broda and Baxter, 2002).

2.8 Metadata

The previous four sub-sections have outlined how digital geographic information is being used at the K-12 level. What is lacking in many of the existing materials documenting digital geographic information at the K-12 level is how well students understand the unifying concepts surrounding digital geographic information (McWilliams and Rooney, 1997). An example of one concept is metadata. Metadata refers to the supporting information which describes geographic information (Burroughs and McDonnell, 1998). Within metadata are descriptions of data quality, projection systems, reference systems, and copyright issues. Consideration of metadata is important when working with digital geographic information because digital geographic information can be combined with supplementary sources of geographic and non-geographic information to conduct further analyses (Heywood et al., 1998). Producing and using metadata is an important part of teaching students how to use digital geographic information. Unfortunately, metadata is a topic which is neglected in K–12 discussions of geographic information (McWilliams and Rooney, 1997).

The lack of concepts such as metadata in the literature surrounding the usage of geographic information at the K-12 illustrate how the essential concepts and abilities for using digital geographic information at the K-12 level have not yet been identified (Obenhaus, 1990). Prior to the development of standards and curricula for geographic information literacy, it is crucial that a level of agreement is present among geographic information experts on the issue of geographic information literacy. A starting point for this process would be to consult those familiar with geographic information, in an effort to identify knowledge that is appropriate for K-12 education (Bianchi and Kelly, 2003).

2.9 Geographic Education in British Columbia

This thesis uses British Columbia as a case study for the study of geographic information literacy; therefore it is relevant to outline the current state of geographic education in the province. The social studies program in the Province of British Columbia is currently in transition. In the past, geography has experienced a low profile in the social studies curriculum, with Geography 12, an elective course, representing most students' only major exposure to geography. However, a dedicated group of educators have worked hard to improve the profile of geography in the K-12 curriculum.

These educators have been helped by the *British Columbia Social Studies Task Force* (1999), who in their final report concluded that social studies is in a state of crisis. In particular, the task force noted that many teachers are teaching social studies with inadequate background and knowledge of the subject area (Social Studies Task Force, 1999). There is a belief that anyone can teach social studies. The taskforce also noted the lack of inspiring materials and methods for teaching social studies. Their primary recommendation was for the Ministry of Education to support the creation of networks for teacher development in social studies (Social Studies Task Force, 1999).

In response to the *Social Studies Task Force Report*, the Ministry of Education has provided financial resources for a number of projects to improve geographic education in the province. The *Geography Connections Program*, led by Dale Gregory, was developed to facilitate the creation of a network to support social studies teachers in British Columbia. The program seeks to link teachers, school districts, professional associations and university geography departments into a common project (Ministry of Education, 2001). The partners have collaborated to develop a project composed of three interrelated parts: a series of workshops, a website and a centre for enhancing the teaching of geography (Ministry of Education, 2001). The project focuses on the intermediate and secondary grade levels and provides teachers with professional development, professional support and geography curriculum materials for addressing the shortcomings of the social studies curriculum.

Geography Connections Program coincides with Ministry of Education's licensing of GIS software packages Arc View® and Geo Media®. All schools province wide can obtain copies of these packages at no charge (ESRI, 2001). A CD is also in development that will provide teachers with sample GIS lessons to align with British Columbia's curriculum for social studies and geography. Copies of the CD Rom will be available free of charge starting October 2003 (Dye, 2003).

The *Geography Connections program* has also helped to develop "The Environmental Organizer" website (http://www.geog.ubc.ca/activities/). This website was developed by Margaret North and Sally Hermansen of the University of British Columbia. The website is an additional resource for teachers interested in teaching geography with an emphasis on fieldwork. The site's resources are searchable by grade level and curriculum objectives.

2.10 Conclusions

The continuous progression to an information-based economy has increased the public's reliance on digital information. With the transition taking place from traditional to digital sources, it is necessary to re-evaluate what knowledge is required to use digital information in an information-based economy. One part of the transition involves providing students at the K-12 level with IT education as part of their overall education. To help students make their way through the vast quantities of digital information now available, students should receive information literacy training as part of their IT education.

Geography has benefited from the move towards an information-based economy. Improvements in digital technology have exposed geographic information to a wider audience. In response, it is necessary to re-evaluate what knowledge is necessary to use geographic information. This understanding can be termed geographic information literacy. K-12 is where geographic information literacy should be encouraged in order to provide students with the knowledge, abilities and habits of mind they need to use contemporary forms of geographic information later in life. The usage of digital geographic information at the K-12 level also satisfies the demands for IT education imposed on the education system.

At the K-12 level digital geographic information is receiving attention as an alternative to existing techniques for teaching geography. Educators have used GIS, remote sensing, digital atlases and global positioning systems with differing results. However, educators have yet to introduce students to key geographic information concepts, such as metadata. In British Columbia geographic education is in a state of transition. Provincial officials have recognized the need to change how geography is taught at the K-12 level. As a result, an emphasis has been placed on developing networks to support geography teachers and to improve the breadth of instructional materials and methods available to geography teachers. The next step in the research is to consult with experts in geographic information to more clearly define the attributes of GIL that are appropriate for K-12 education in British Columbia.

3. METHODOLOGY

3.1 Introduction

The objective of this study was to use an online questionnaire to define the critical features of geographic information literacy (GIL) and content analysis to examine the status of GIL in British Columbia's K-12 education curriculum. To this end, the methodological approach was to commence with an online questionnaire to identify what experts in and users of traditional and digital geographic information thought should be taught at the K-12 level. Sections 3.2, 3.3, and 3.4 explain the design and distribution of the online questionnaire. The results identified as essential and important by questionnaire respondents were used to carry out a content analysis of selected portions of British Columbia's existing K-12 curriculum. Section 3.5 provides background on British Columbia's existing K-12 curriculum documents.

Sections 3.6, and 3.7 illustrate how the results of the online questionnaire were used for a content analysis of curriculum documents. A coding frame of keywords was developed from results identified as essential and important by questionnaire respondents. The keywords from the coding frame were used in conjunction with the content analysis software NUD*IST® 5 (Non-Numerical Unstructured Data Indexing Searching and Theorizing), to analyze relevant portions of British Colombia's K-12 education curriculum. Section 3.8 explains how the NUD*IST® 5 content analysis software was used in this study. Figure 3.1, outlines the sequence of this research methodology.

3.2 Online Questionnaire

The Internet provides new possibilities for social researchers (Madge and O'Connor, 2002). Online surveys are seen as an efficient alternative to conventional survey techniques, such as mail out questionnaires, and do not appear to reduce data quality (Babbie, 2000; Couper et al., 2000). Dillman (1978) developed a successful method for conducting mail questionnaires using the "total design method". Approaches used for mail questionnaires are now being adapted to complement online questionnaires (Crawford et al., 2001).

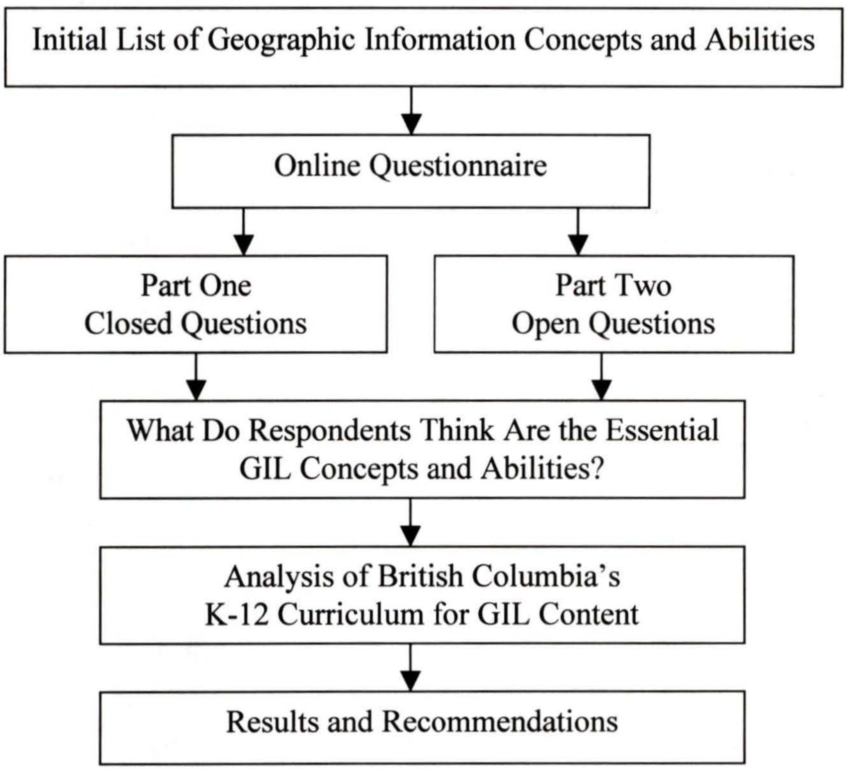


Figure 3.1: Flow Chart of Research Methodology

Online surveys allow researchers to access a large and diverse population of individuals and groups (Coomber, 1997). Gaddis (1998) suggests several reasons for a shift towards online surveying techniques:

- online surveys are relatively inexpensive to design and conduct;
- online surveys tend to have high response rates and quick return times in comparison to mail out questionnaires;
- there is less interference from people and institutions who could prevent surveys from being delivered to respondents; and
- a large and growing portion of society is using the Internet, with approximately seventy million people worldwide now having online access.

With mounting interest in the use of online surveys, this data collection method was chosen to solicit the opinions of geographic information experts and users. Geographic information experts and users were asked for their opinions on the issue of geographic information at the K-12 level. The objective of the questionnaire was to utilize their responses to refine an initial list of geographic information concepts and abilities, developed by the researcher, into a concise list of essential concepts and abilities of GIL appropriate for inclusion in British Columbia's K-12 curriculum. The questionnaire used closed and open questions to complete this task.

Following the development of both the closed and open questions, the questionnaire was piloted to graduate students and research assistants from the University of Victoria's Department of Geography. The feedback from the pilot helped to improve the design of the questionnaire; issues such as ambiguous language and unclear instructions, for example were brought to light as a result of the pilot. Also, graduate students and research assistants provided suggestions about concepts and abilities that they felt should be included in the questionnaire. Many of their suggestions were included in the final draft of the questionnaire.

3.2.1 Closed Questions

Respondents were asked to review a broad list of geographic information (GI) concepts and abilities for the closed portion of the questionnaire,. For the purposes of this study the Oxford English Dictionary's definitions of concepts and abilities were used as a reference. They define "concepts" as "notions or ideas" while "abilities" refer to "being able to do a given task". The initial list was created by an informal content review of primary written sources specializing in geographic information (Appendix One). Concepts and abilities common to all or several of the reviewed materials were included in the list. The primary source materials were books, journal articles, and web-based materials related to the usage of geographic information. These included materials related to cartography, remote sensing, Geographical Information Systems (GIS), information literacy, statistics and geographic education (Appendix One).

This list was subsequently shaped with the assistance of in-house consultants (University of Victoria's Spatial Sciences Laboratory) with geographic information experience. Members of the laboratory were consulted about which concepts and abilities they considered essential for the usage of geographic information. They were also shown drafts of the list and ask to comment on whether the list included concept and abilities which were appropriate. With the assistance of in house expertise, the initial list of concepts and abilities went through several iterations. Their assistance helped to focus the initial list into a final list that included concepts and abilities which were fundamental to the usage of geographic information, in either its traditional or digital formats

(Appendix Two). Once completed, the list was separated into three categories (Table 3.1).

Grouping	Materials Covered
Traditional Geographic Information	Concepts and abilities for using traditional analog geographic information
Digital Geographic Information	Concepts and abilities for using digital geographic information
Information Literacy	Concepts and abilities for handling all types of information

Table 3.1: Subject Groupings of the Closed Questionnaire

. The list obviously includes concepts and abilities of specific and direct relevance to digital geographic information. However, traditional geographic information (e.g. paper maps and atlases) concepts and abilities still have value in the digital world. A full understanding of traditional geographic information concepts is essential for those working with digital geographic information, as they both utilize the similar underlying principles (DiBiase, 1996; Peterson, 1997). Finally, information literacy concepts and abilities were included in the list to provide geographic information users with knowledge relevant to all types of information. This component of the overall list builds on the work of Carter-Peoples and Krygier (2002), who have adapted existing definitions of information literacy to suit the library needs of geography students.

From the initial examination of the source materials, a list of eighty-one applicable concepts and abilities was created as an online questionnaire (see Appendix Two). Geographic information users were asked to rate the list of geographic information concepts and abilities using a five-point scale, ranging from "essential" to "not appropriate" (Table 3.2). The scale allowed respondents to express their position on the value of an ability or concept to K-12 geographic information literacy.

<table>
<tr><th>Possibilities</th><th>Value</th></tr>
<tr><td>Essential</td><td>Very important. Should already be in the curriculum.</td></tr>
<tr><td>Important</td><td>Needing review to see if it would be appropriate for the curriculum.</td></tr>
<tr><td>Optional</td><td>Could be included in a full K-12 course on Geomatics</td></tr>
<tr><td>Not Important</td><td rowspan="2">Should not be included in the K-12 curriculum. These results are should not be considered essential for GIL at the K-12 level.</td></tr>
<tr><td>Not Appropriate</td></tr>
</table>

Table 3.2: Rating Scale for the Geographic Information Literacy Questionnaire

For the purposes of analysis, results were ranked as "3" for essential, "2" for important and "1" for optional. Due to the ordinal nature of the responses the remaining two options were coded as zero. A zero code was given to these responses because these responses were not the focus of the research, and therefore they were not included in further analysis. The research focused on the concepts and abilities rated as essential and important by respondents. This decision removed approximately five percent of the total responses (8851). The low number of not important and not appropriate responses suggests that respondents were satisfied with the concepts and abilities presented in the closed portion of the online questionnaire.

3.2.2 Open Questions

In part two of the questionnaire, respondents were asked to give their personal opinions concerning the concepts and abilities that they felt were important for K-12 geographic information literacy. Open questions were separated into three parts: traditional geographic information, digital geographic information, and information literacy. For each section respondents were given open text fields to enter a concept or ability. They were also asked to rank each value using a three-point scale, mirroring the system used in part one of the questionnaire (Table 3.3):

Number	Rating Scale
3	Essential
2	Important
1	Optional

Table 3.3: Rating Scale for Open Question Responses

The rationale for including the open questionnaire was to allow the respondents, geographic information users, an opportunity to emphasize concepts and abilities from part one or to add to the working list of concepts and abilities essential to GIL. Open questions are useful when conducting exploratory research, especially in situations where the researcher is not clear about the range of responses (Palys, 1998).

Open questions are suited for collecting respondent's opinions in their own words (Sheatsley, 1983). This type of question is useful for gathering ideas that are important to respondents, as people tend to mention matters important to them first (Kahneman et al., 1982). Also, open questioning corrects for oversights and biases of the group developing the questionnaire. Overall, open questions allowed geographic information users to express a range of opinions concerning geographic information literacy at the K-12 level. However, a poor response rate to the open questions prevented any meaningful comparisons with the closed questions. A descriptive summary of the results from the open questions is presented in Chapter Four.

3.3 Web Design of the Questionnaire

The completed questionnaire was posted online using the University of Victoria, Department of Geography's server (http://godzilla.geog.uvic.ca/gil/index.htm), upon approval from the University of Victoria's Human Subjects Committee. A copy of the online questionnaire is included in Appendix Three. The website that housed the questionnaire was designed with the Macromedia Dreamweaver® 4 software package. The design of the questionnaire was kept simple and straightforward, as it was believed that unnecessary features would have distracted the user's attention away from the overall goal of completing the questionnaire. Design considerations are crucial when designing any type of survey material (Babbie, 2000; Gaddis, 1998). With online survey materials design decisions can influence people's reactions to the material and can affect the number of responses (Couper et al., 2001). The questionnaire portion of the website consisted of four individual web pages. The first page contained 81 closed questions. On this page, radio buttons were used to represent the five-point ranking scale described in Section 3.2.1. Respondents used this scale to rank the importance of concepts to K-12 geographic information literacy (Figure 3.2).

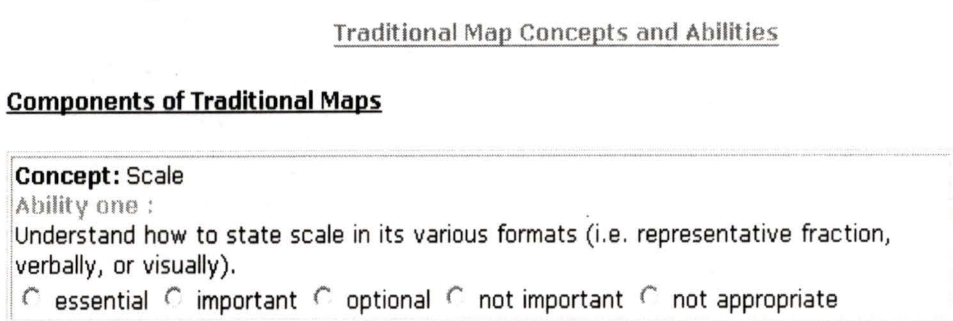


Figure 3.2: Layout of Closed Questions in Part One

Radio buttons were favoured in questionnaire design because respondents prefer to select their preferred responses via a mouse click as opposed to filling out text boxes thereby reducing the issue of blank or missing responses (Couper et al., 2003).

At the bottom of the first web page were a series of background questions. The background information helped to describe the people who were completing the questionnaire. Background questions asked included level of education, occupation, and country of current residence. The information collected was used to investigate if demographic factors influenced how geographic information users answered the closed portion of the questionnaire.

Following the closed question web page were three additional web pages which housed the open portion of the questionnaire. Each page represented a sub-grouping from part one of the questionnaire: traditional geographic information, digital geographic information, and information literacy. Each page had ten open text boxes for respondents to enter their comments. Alongside each text box was an additional box for their rating of that response (Figure 3.3). Upon completion of the questionnaire, there was a final page thanking respondents for their participation.

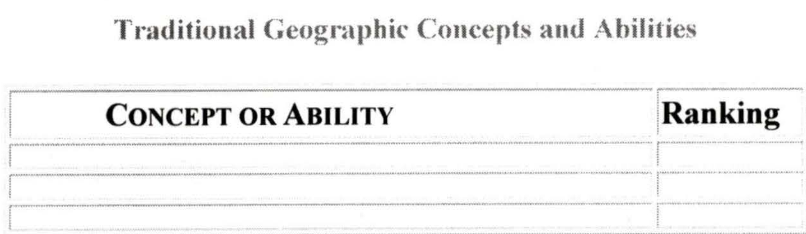


Figure 3.3: Layout of Open Questions in Part Two

3.4 Distributing the Questionnaire

The questionnaire was available online from January 19, 2003 to February 28, 2003. In order to publicize this project an email introducing the project was sent to potential respondents through targeted list-servers. Targeted list-servers were those belonging to organizations that generally discuss the usage of geographic information. Other groups were targeted because of their interest in building geographic education at the K-12 level. The following is a list of targeted organizations:

- CAG – Canadian Association of Geographers
- CCA - Canadian Cartographic Association
- ACMLA – Association of Canadian Maps Librarians and Archivists
- NCGE - National Council of Geographic Education
- CCGE – Canadian Council of Geographic Education

The organizations targeted for the distribution of the questionnaire are located within Canada and the United States. However, professionals residing outside these countries can join these organizations and be included on their list-servers. As with standard survey procedures, a follow-up email was sent to potential respondents two weeks after the initial message. The message was sent two weeks after the initial message because at the two week point there was a significant decline in the number of responses received. The follow up message reminded members of these organizations about the questionnaire and provided a URL for the questionnaire's website. The results of the questionnaire are summarized in Chapter Four.

3.5 Curriculum Materials

The source materials for the content analysis were British Columbia's Integrated Resource Packages (IRP). The publicly accessible documents were obtained from the Ministry of Education's website (http://www.bced.gov.bc.ca/irp/). The IRP documents consist of the following:

- provincially required curriculum (learning outcomes);
- suggested ideas for instruction;
- a list of recommended learning resources (e.g. books, videos, electronic resources); and
- possible methods for teachers to use in evaluating students' progress.

The learning outcomes put forth by British Columbia's Ministry of Education are statements of what students are expected to know and do at an indicated grade level. British Columbia was targeted for the content analysis because its' K-12 curriculum is of direct interest to the researchers involved in this study, and because the University of Victoria is located in the province of British Columbia. Focusing on British Columbia was also convenient because the Ministry of Education is based in Victoria and the University of Victoria has a Faculty of Education. As a result, local education experts were available for consultation when necessary. The required curriculum materials for the content analyses were easily accessible in either paper or digital format.

For the purposes of this research, only the learning outcomes of relevance to geographic information literacy were analyzed. Specifically, the curricula for the following grades and subject areas were targeted:

- Social Studies K-7
- Social Studies 8-10
- Social Studies 11
- Geography 12
- Earth Science 12
- Information Technology 8-10
- Information Technology 11
- Information Technology 12
- Science K-10
- Mathematics K-12

Social studies, and geography curricula were targeted because they are subjects where geographic information is most likely to be found. Information technology 8-12 was included because these curricula focus on the usage of digital information (Ministry of Education, 1999). Although, mathematics and science curricula may not contain specific references to geographic information, these documents contain references to general concepts and abilities which are necessary foundations for geographic information literacy in K-12. Included in the content analysis was also the curriculum for Ontario's Geomatics 12 course. This exception was included because it is the only K-12 course in Geomatics offered in Canada.

In order to facilitate the content analysis, IRP documents were converted from Adobe's (*.pdf) format into a text file (*.txt). This was done because NUD*IST® 5 software only reads text files. At this stage, documents were further separated by grade level. The breakdown was done to reduce the individual size of files and to analyze the content of the curriculum by grade level.

3.6 Content Analysis

The completion of the online questionnaire led into a content analysis of curriculum documents discussed in Section 3.5. Text materials, such as textbooks and government legislation, are ideal candidates for content analysis (Bauer, 2000). Text documents provide information about the author's plans and feelings. Computer and software innovations have renewed interest in content analysis as a tool in qualitative research (Kelle, 1995). Renewed interest in content analysis is also an outcome of the public's acceptance of the Internet and subsequent growth of online text archives for media such as newspapers, radio and television programs (Bauer, 2000). As a result, qualitative researchers are gradually accepting software-based methodologies for the analysis of qualitative data (Dohan and Jankowski, 1998). Content analysis software packages allow researchers to search for root forms of words or synonyms, to use wildcard characters, and to produce combination searches (Dohan and Sanchez-Jankowski, 1998). The qualitative software package NUD*IST® (Non-Numerical Unstructured Data Indexing Searching and Theorizing) 5 was used for this research because it allows for simple and efficient management of curricula documents (Kitchin et al., 1998).

3.7 Coding Frame

Prior to content analysis of the IRP documents, a geographic information literacy-coding frame was developed. The foundation for the coding frame was the results of the online questionnaire. Coding is a pivotal component of qualitative content analysis (Kelle, 1995). Developing such a framework often involves a period of trial and error.

Classifying and coding of materials are iterative processes, bringing together theory and research materials (Bauer, 2000; Palys, 1992). The objective of coding is to produce a clearly defined and non-overlapping coding framework.

The coding frame for this research was based on questions from the online questionnaire rated as essential (modal value of three) and important (modal value of two). Questions ranked as essential and important by respondents may be argued to be very important to the usage of geographic information, and therefore should already be in the curriculum. Coding frames were developed from essential and important closed question responses to represent the three facets of GIL: traditional geographic information, digital geographic information and information literacy. Coding frames for each sub-group were created by de-constructing questions into key words and phrases (Suchan and Brewer, 2000). The results of this process were reviewed to include synonyms of terms or to soften technical jargon into terms suitable for analysis of the K-12 curriculum.

The drafts of the coding framework were tested by the researcher to ensure that the coding frame identified subject matter related to geographic information literacy. For the purposes of this research, drafts of the coding frame were tested on sample portions of the IRP documents prior to the start of the analysis. This step helped to ensure that the final coding frame used for analysis accurately identified GIL content in the IRP documents.

3.8 Content Analysis of the IRP documents

The IRP documents and the GIL coding frame were imported into the NUD*IST® 5 software. The sequence for the application of the coding frames on the IRP documents was:

1. traditional geographic information;
2. digital geographic information and
3. information literacy.

The text search option available as part of the NUD*IST® package was used to explore how often and in what context the terms from the coding frame occurred in the IRP documents. The NUD*IST®5 software also allowed for a text search of numerous documents at one time. The multiple search option made it possible to scrutinize several IRP documents simultaneously and improved the efficiency of the research. Following the text search, the software produced a report describing how many times a keyword or phrase occurred in a document. The results of the content analysis are summarized and discussed in Chapter Five.

3.9 Summary

This chapter outlined the methods used to collect and analyze the data presented in this thesis. Methods included:

- development of an initial list of geographic information concepts and abilities;
- an online questionnaire targeted at geographic information users; and

- content analysis of selected portions of British Columbia's current K-12 curriculum and Ontario's Geomatics 12 course.

The following chapters will discuss the results obtained from the questionnaire and from content analysis of the curricula.

4. RESULTS OF ONLINE QUESTIONNAIRE

4.1 Introduction

An online questionnaire was distributed to geographic information users. The purpose of the questionnaire was to collect opinions regarding what students should know about geographic information by the completion of their K-12 education. Section 4.2 characterizes the respondents of the questionnaire. Section 4.3 describes the concepts and abilities that were rated as essential for K-12 geographic information literacy and includes a breakdown of the questionnaire results by category namely traditional geographic information, digital geographic information, and information literacy. Section 4.4 compares respondents' digital and traditional geographic information responses. Section 4.5 compares the results of Section 4.4 with the respondents' demographic information. Sections 4.6 through 4.8 examine the open question portion of the questionnaire. Section 4.9 assesses the methodology employed in this component of the research. The results of the questionnaire will be used to address three research questions:

- Which concepts and abilities do geographic information users believe are essential, important, and optional for K-12 users of geographic information?
- Do geographic information users have a preference about what types of geographic information should be taught at the K-12 level?
- Do demographic factors such as age, education, location and profession affect geographic information users preferences?

4.2 Questionnaire

As already noted in Section 3.4, the two-part questionnaire was posted online from January 19th, 2003 to February 28th, 2003. Upon completion of the posting, 80 useable responses were received. A complete description of the respondents' demographic information is included in Figure 4.1(a-d). The age of questionnaire respondents was somewhat bimodal, peaking with the 30 to 39 and 50 to 59 age groupings.

Most respondents were educational professionals with high levels of education. Seventy-eight percent of the respondents reported education as their profession, although it is not clear from the questionnaire at what educational levels the respondents were working. Seventy-two percent of questionnaire respondents reported completing a graduate degree. The high percentage of respondents with graduate qualifications may indicate a strong influence by post-secondary educators in the respondent sample.

4.3 Closed Questions

Eighty closed question responses were received in the six weeks the questionnaire was online. Of the eighty responses received, only one response had to be excluded. This individual completed the traditional portion of the questionnaire, but did not complete the digital component. As a result, the individual's traditional responses were included in the results and their digital responses were coded as missing.

Figure 4.1a: Geographic Profile of Questionnaire Respondents

Location of Respondents	**#**
Canada	44
United States	27
Other	3
Missing	6
Total	**80**

CANADA

Province	**#**
British Columbia	15
Alberta	3
Saskatchewan	1
Ontario	12
Quebec	1
Nova Scotia	1
Canada	11
Total	**44**

UNITED STATES

States	**#**
Arizona	1
California	5
Colorado	1
Illinois	2
Louisiana	1
Maryland	1
Massachusetts	1
Michigan	1
Minnesota	1
Nevada	1
New Hampshire	1
New York	2
North Dakota	1
Ohio	2
Texas	1
Vermont	1
United States	4
Total	**27**

OTHER

Country	**#**
Japan	1
New Zealand	1
United Kingdom	1
Total	**3**

Figure 4.1b: Respondents Age Range

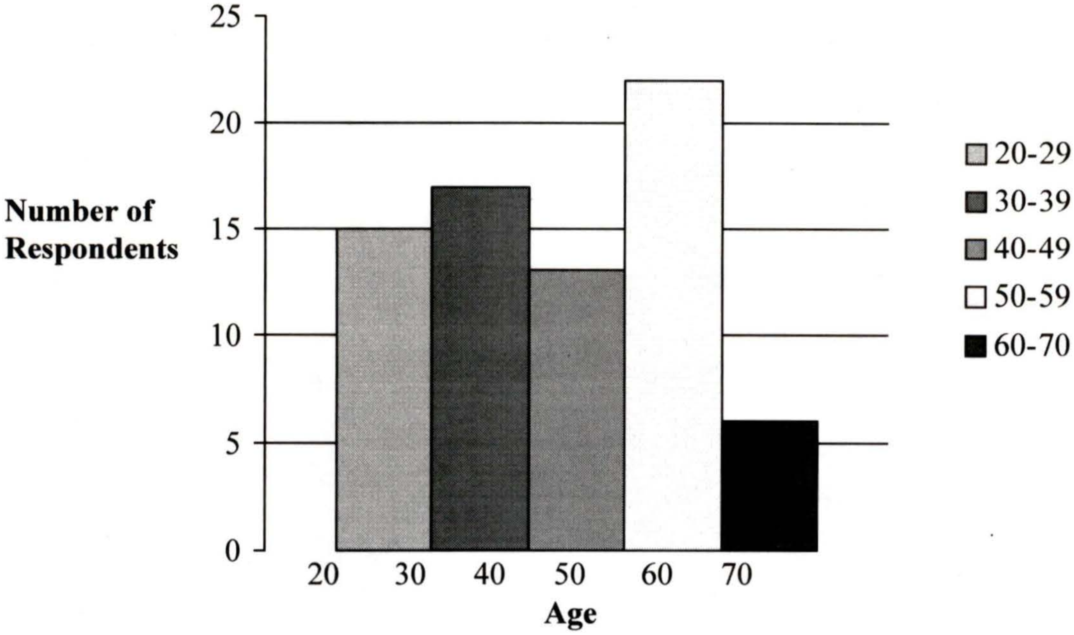


Figure 4.1c: Respondents by Profession

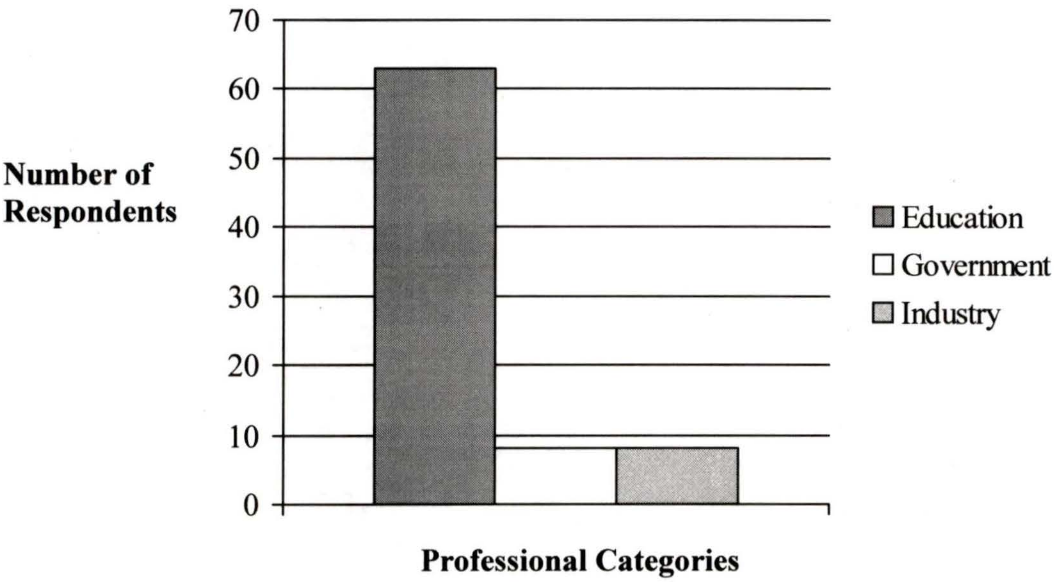
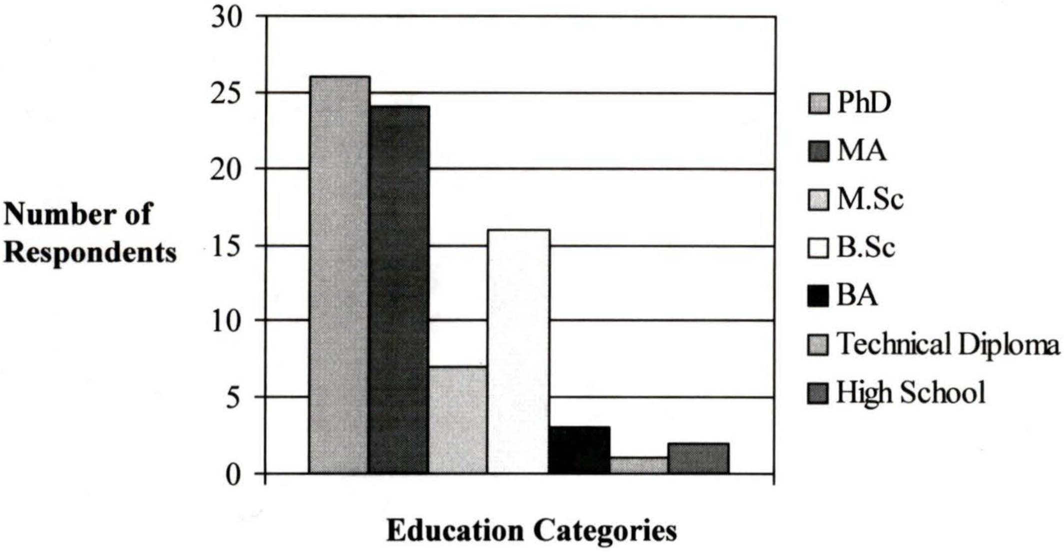


Figure 4.1d: Respondents by Education



The consolidated dataset was imported into SPSS® and the mode, range, and mean ranking for each question were calculated. Appendix Four gives a complete listing of the closed questionnaire results organized in the order they appeared to respondents. The purpose of calculating the three descriptive statistics was to explore the results, and to separate out the responses based on their importance to K-12 geographic information literacy. Questions were grouped as follows:

- modal values of three represent essential concepts and abilities;
- modal values of two represent important concepts and abilities; and
- modal values of one represent optional concepts and abilities;

Mode was selected as the primary discriminating value, as the data is ordinal in nature. Following the primary grouping by mode, each group was secondarily sorted by mean ranking. The purpose of the process was to create a list ordered from essential to optional. Table 4.1 is an overall list of the 16 concepts and abilities which respondents rated as essential for K-12 geographic information literacy.

Concept Ability*	Description	Type
a	Calculate distance on map using its stated scale.	t.
c	Understand how to locate objects and features using latitude/longitude	t.
a	Ability to obtain information by reading symbols on a map.	t.
a	Calculate distances between points on a map.	t.
c	Understand how to measure direction in reference to four cardinal directions.	t.
c	Understand how to state scale in its various formats (i.e. representative fraction, verbally, or visually).	t.
c	Understand how to locate objects on a Cartesian grid.	t.
c	Understand how to specify locations using coordinate systems on a topographic map (i.e. Lat/long and UTM coordinates).	t.
a	Ability to identify visual patterns on a thematic map.	t.
a	Obtain elevations by reading contours.	t.
c	Understand the difference between quantitative and qualitative information.	i.
c	Understand how to use cardinal directions to take a bearing.	i.
c	Understand the proper uses of charts and graphs.	i.
c	Understand the difference between primary and secondary information.	i.
a	Successfully convert between units of measurement i.e. metric to imperial.	i.
c	Understand how to search the Internet for geographic information.	d.

* c = concepts and a= abilities **Type: t= traditional, d= digital and i =information literacy

Table 4.1: Overall Essential Geographic Information Concepts and Abilities

The results were further sub-divided based on the sub-groupings: traditional geographic information, digital geographic information and general information literacy. Tables 4.2, 4.4, and 4.5 outline the top ten concepts and abilities for each group sorted by mode, and secondarily by mean. Table 4.1 shows that traditional geographic information concepts and abilities dominate the essential grouping.

Concept or Ability*	Description	Mode	Mean Rank
a	Calculate distance on map using its stated scale.	3	2.7
c	Understand how to locate objects and features using latitude/longitude	3	2.7
a	Ability to obtain information by reading symbols on a map.	3	2.6
a	Calculate distances between points on a map.	3	2.6
c	Understand how to measure direction in reference to four cardinal directions.	3	2.6
c	Understand how to state scale in its various formats(i.e. representative fraction, verbally, or visually).	3	2.6
c	Understand how to locate objects on a Cartesian grid.	3	2.5
c	Understand how to specify locations using coordinate systems on a topographic map (i.e. Lat/long and UTM coordinates).	3	2.5
a	Ability to identify visual patterns on a thematic map.	3	2.4
a	Obtain elevations by reading contours.	3	2.4

c = concepts and a= abilities

Table 4.2: Top Ten Traditional Geographic Concepts and Abilities

These results suggest questionnaire respondents believe that traditional geographic information concepts and abilities remain an essential part of a K-12 student's geographic information education. The traditional geographic information concepts and abilities listed as essential by geographic information users should be included in the K-12 curriculum (Chapin and Messick, 2002; Kirman, 1996). For example, Table 4.3 illustrates the traditional geographic information concepts and abilities that students are expected to be capable of by the end grade six, and how these concepts and abilities were rated in the questionnaire. Geographic information users ranked all but one of the five concepts and abilities mentioned by Kirman, (1996) and Chapin and Messick, (2002) as essential (Table 4.3). Knowing how to use a compass was rated as important. These core geographic information concepts and abilities form the basis for a student's map usage at higher grades.

Concept or Ability	Questionnaire Rating
Recognize a map and know how it can be used.	Essential
Know the points on a compass.	Important
Understand differences in scale.	Essential
Be able to locate themselves on a map.	Essential
Have knowledge of latitude and longitude.	Essential

Table 4.3 Geographic Information Concepts and Abilities Students Should Possess by Grade Six and Their rating in the Questionnaire (Chapin and Messick, 2002; Kirman, 1996).

In terms of the top ten digital geographic information concepts and abilities (Table 4.4) only one concept was rated as essential, namely *Searching the Internet for geographic information.* Digital geographic information concepts and abilities tended to be rated as important (mode of two) by respondents. The important concepts and abilities focused on the proper usage of digital geographic information. Respondents ranked many of the digital geographic information concepts involving technical issues in the optional range (mode of one). This results suggest geographic information users believe that at the K-12 level, students should be exposed to the proper usage of digital geographic information. Students should be taught the concepts and abilities that will allow them to locate and understand how to use geographic information, whatever medium. However, further research is necessary on the issue of digital geographic information to identify which concepts and abilities are appropriate.

Concept or Ability*	Description	Mode	Mean Rank
c	Understand how to search the Internet for geographic information.	3	2.2
c	Comprehension of how resolution affects the level detail in geographic information.	2	2.2
c	Understand how geo-technologies are being used in society	2	2.2
c	Understand how to identify the coordinate system of a digital map.	2	2.1
c	Understand copyright and ownership issues associated with geographic information.	2	2.0
c	Understand the limitations of geographic information gathering tools or strategies and the conclusions drawn from these tools.	2	2.0
c	Understand the ethical, legal and socio-economic issues surrounding geographic information and information technologies.	2	1.9
c	Understand how to Identify the projection of a digital map.	2	1.9
c	Understand how to properly document geographic information	2	1.8
c	Understand how to process GPS information into a useable format.	2	1.8

c = concepts and a= abilities

Table 4.4: Top Ten Digital Geographic Information Concepts and Abilities

In terms of information literacy, four concepts were ranked as essential in the top 10 concepts and abilities as identified by respondents (Table 4.5). The essential concepts and abilities for information literacy focused on understanding different forms of information. As students are exposed to greater amounts of information, they require the concepts and abilities that allow for the effective usage of information (Plotnick, 2000). Also, all four essential information literacy concepts outranked the only digital geographic information concept ranked as essential. A higher ranking for information literacy concepts suggests respondents are still not sure if digital geographic information is an essential component for the K-12 education. More work is necessary to inform geographic information users about the educational possibilities for digital geographic information at the K-12 level.

Concept or Ability*	Description	Mode	Mean Rank
c	Understand the difference between quantitative and qualitative information.	3	2.4
c	Understand the proper uses of charts and graphs.	3	2.3
c	Understand the difference between primary and secondary information.	3	2.3
a	Successfully convert between units of measurement i.e. metric to imperial.	3	2.2
c	Understand how to assess information for currency, completeness and cost.	2	2.0
c	Understand how errors can propagate through a dataset.	2	2.0
c	Familiarity with different levels of measurement (nominal, ordinal, interval and ratio).	2	1.9
a	Understand the difference between absolute and derived data.	2	1.9
c	Understand how to differentiate between accuracy and precision.	2	1.9
c	Demonstrate an ability to design and populate an attribute database.	2	1.8

* c = concepts and a= abilities

Table 4.5: Top Ten Information Literacy Concepts and Abilities

4.4 Users' Opinions Towards Traditional and Digital Geographic Information

The closed portion of the online questionnaire was divided into traditional and digital geographic information (for an explanation of this division see Section 3.2.1). There are forty-three questions involving digital geographic information topics and thirty-eight questions involving traditional geographic information topics. The objective of comparing the two forms of geographic information was to see if respondents have differing opinions about the importance to K-12 education of concepts and abilities associated with either type of information.

Respondents' answers to digital and traditional geographic information questions were coded from **three** for essential responses to **zero** for not appropriate and not important responses. The recoded resposnes were then summed to create a pair of scores. This approach violates a key assumption of ordinal data. However, in order to present an aggregate exploration of the eighty-one questions it was deemed appropriate to violate the assumption. The highest score possible for traditional geographic information is 114 and for the digital geographic information is 129. Traditional and digital scores were also standardized to account for the higher number of digital responses in the questionnaire. Scores were standardized on a scale from zero to one hundred. The following formula was used to standardized the values:

$$\frac{(V - \min V)}{(\max V - \min V)} \quad *100$$

V= Original Value
Max *V* = Maximum value in the dataset
Min *V* = Minimum value in the dataset

This standardization method allows variables to have differing means and standard deviations but equal ranges. In this case, there is at least one observed value at the zero and one hundred endpoints (Gower, 1985; Johnson and Wichern, 1992). Descriptive statistics for the raw and standardized digital and traditional geographic information scores are presented in Table 4.6. Also, a K-S test for normality was carried out on both traditional and digital scores, and both scores are normally distributed at a ninety-five percent confidence interval. Figure 4.2 provide histograms for both traditional and digital standardized scores.

Statistics	Digital Raw	Digital Standard	Traditional Raw	Traditional Standard
Count	79	79	80	80
Median	67	43.7	73	55
Inter Quartile Range	27	26	19	26
Mean	69.3	45.3	73.8	56.7
Standard Deviation	19.5	18.7	13.7	19.1
K-S Test	.710	.710	.993	.993

Table 4.6: Descriptive Statistics for Traditional and Digital Geographic Information Scores

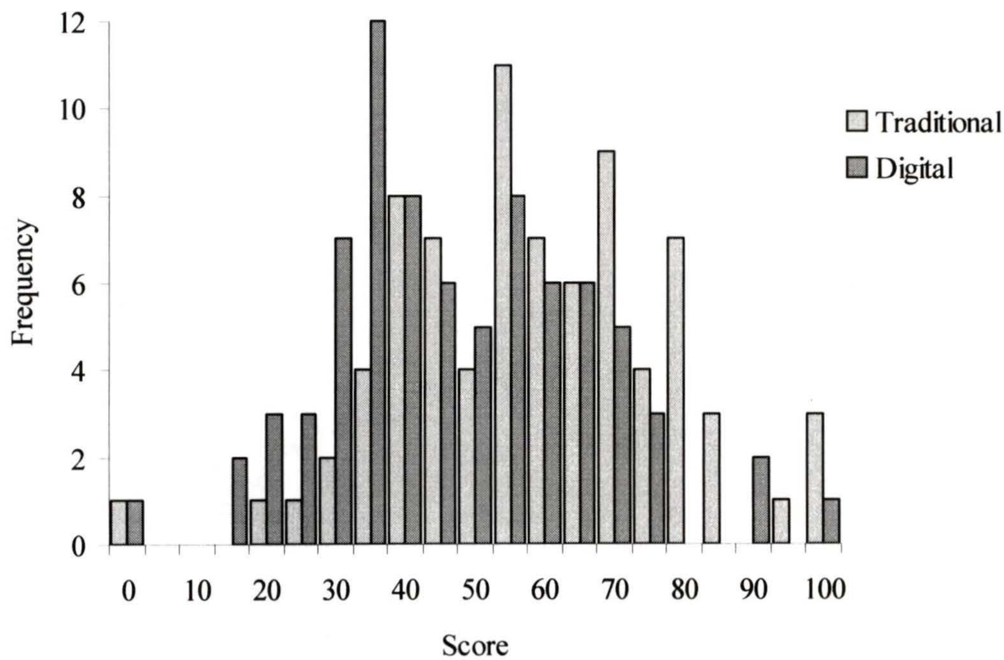


Figure 4.2: Distributions of Standardized Traditional and Digital Geographic Information Scores

A statistical comparison of the means for both scores suggests that respondents ranked traditional geographic information higher ranking than digital geographic information (Figure 4.2). A t-test was used to compare the means of both standardized scores (t = -6.492 and sig.= .001, with 78 degree of freedom). The results indicated that there was a statistically significant difference between the means of both scores at a ninety-five percent confidence interval. However, this result should not be taken to imply that traditional geographic information is more important than digital geographic information. These results are exploratory and further research is necessary on the issue of GIL to determine if one form of geographic information is more important than another. At this time, curricula for teaching traditional geographic information at the K-12 level are well established. Educators have been teaching a set group of concepts and abilities for decades. Conversely, digital geographic information is a new addition to the K-12 education system and curricula for digital geographic information have not yet been developed. When a new innovation is introduced into to the classroom, there is period of disagreement in regards to its place in the classroom (Cuban, 1986). With time it is assumed that, digital geographic information will find its place in the hierarchy of educational technologies.

4.5 Demographic Results of Digital and Traditional Scores

The scores derived from the closed questions and the collected demographic information were also analyzed to determine if factors such as age, profession and education had an affect on responses. Chi-square and correlation were employed to examine relationships between responses and demographic information. Digital and traditional scores calculated in Section 4.4 were compared with the demographic information collected as part of the closed questionnaire. In order to perform the statistical analyses with the demographic information, the scores calculated in Section 4.4 had to be recoded. The digital and traditional geographic information scores were recoded into equal three classes. Tables 4.7 and 4.8 show the recoded values for the digital and traditional values.

Recoded	Range
A	0-33
B	33.1-66
C	66.1-100

Table 4.7: Recode of Digital Geographic Information Standardized Scores.

Recoded	Range
A	0-33
B	33.1-66
C	66.1-100

Table 4.8: Recode of Traditional Geographic Information Standardized Scores.

Also, to meet the minimum cell number requirements of the Chi-Square Test, demographic information obtained in the questionnaire had to be recoded. For example, due to the large number of educators who answered the questionnaire, the information about professions was grouped into educators and others. Others were those working in industry or government. For level of education the results were coded as undergraduate and post-graduate, postgraduates includes: master and PhD degrees. Respondents were also given the option to indicate where they were living. The majority of responses were from the United States and Canada. All but three of the responses were from outside of North America. For location information, analysis was carried out ways using the following groupings:

1. Canadian vs. Non- Canadian;
2. British Columbia vs. Canada; and
3. British Columbia vs. Canada vs. United States vs. Outside North America.

Once recoded, the demographic information was used to determine if profession, location and age had an effect on responses to the questionnaire. This lead to the creation of four null hypotheses:

- H_o: Level of education has no affect on how respondents rate traditional and digital concepts and abilities.
- H_o: The profession of a respondent has no affect on how respondents rate traditional and digital concepts and abilities.
- H_o: Where a respondent resides has no affect on how respondents rate traditional and digital concepts and abilities.
- H_o: The age of a respondent has no affect on how respondents rate traditional and digital concepts and abilities.

The Chi-square statistic was used to compare digital and traditional scores, with respondent's education, profession and country of residence. Results were tested for significance at a ninety-five percent confidence interval and summarized as Tables 4.9 and 4.10 (sig. values less than .05 indicate a significant relationship). However, some cells had less than expected values, indicating that the test may not have been robust in these cases. Based on these analyses, there appeared to be no statistically significant relationship between traditional and digital responses and respondent's education, profession and location. The result showing no relationship between location and the respondent's digital and traditional responses is of particular importance to this research. This result showed that questionnaire responses from within British Columbia did not vary from results received from other regions, thus supporting the choice of British Columbia as the location for the case study in Chapter Five. A correlation was used to test the relationship between age and respondents digital and traditional scores. The calculated R-value between traditional and digital geographic information and age indicated no relationship between the two factors at a ninety-five percent confidence interval (Table 4.11).

Variables	Chi Square	Sig.	Reject Null Hypothesis
Education			
Undergraduate vs. Postgraduate	0.06	0.97	**No**
Profession			
Educator vs. Other	0.94	0.63	**No**
Location			
Canada vs. United States and other	1.1	0.59	**No**
British Columbia vs. Canada	0.04	0.98	**No**
British Columbia vs. Rest of Canada vs. United States vs. Other	4.3*	0.63	**No**

*More than two cells with less than expected values

Table 4.9: Chi-square Values for Digital Geographic Information Scores Versus Demographic Information.

Variables	Chi Square	Sig.	Reject Null Hypothesis
Education			
Undergraduate vs. Postgraduate	2.5	0.29	**No**
Profession			
Educator vs. Other	1.2	0.54	**No**
Location			
Canada vs. United States and other	2.5	0.29	**No**
British Columbia vs. Canada	.78	0.68	**No**
British Columbia vs. Rest of Canada vs. United States vs. Other	1.7*	0.43	**No**

*More than two cells with less than expected values

Table 4.10: Chi-square Values for Traditional Geographic Information Scores Versus Demographic Information.

Variables	R-value	Sig.
Traditional Geographic Information	0.16	**No**
Digital Geographic Information	0.17	**No**

Table 4.11: R-values for Age compared to Traditional and Digital Geographic Information Scores.

Overall, none of the four null hypotheses relating to the demographic factors could be rejected. It appears none of the demographic factors had a measurable impact on the questionnaire results. This result suggests the outcomes of the questionnaire are relevant to a wide range of people, and are not influenced by a particular demographic group.

4.6 Open Questionnaire Responses

Following the closed questions, respondents were given the opportunity to include further qualitative opinions about K-12 geographic information literacy. Responses to the open questions are divided into sub-classes: digital geographic information, traditional geographic information and information literacy. Respondents were also given the opportunity to rank their responses (essential concepts =3, important concepts = 2 and optional concepts = 1). In comparison to the closed questions, fewer responses were received for the open responses. The breakdown of responses for the open sections is summarized in Table 4.12:

Sub-classes	#
Traditional Geographic	25
Digital Geographic	22
Information Literacy	9

Table 4.12: Respondents Completing Open Responses

The drop-off in responses limited the types of analysis that could be carried out on the open portion of the questionnaire. However, it was deemed necessary and informative to approach the open responses from a descriptive and qualitative point of view. The open responses provided qualitative insights into the opinions of geographic information users concerning what should be taught to K-12 students about using geographic information. The drop off in response for part two of the questionnaire is in part due to the length of Part One of the questionnaire. Respondents frequently mentioned the length of the questionnaire as an issue that impeded its completion.

Information literacy did not receive sufficient numbers of useable responses to produce a list. Respondents had difficulties identifying concepts and abilities which represented information literacy. In the open text field at the end of the questionnaire, respondents expressed a lack of understanding about information literacy and reported being unfamiliar with the term. However, respondents also mentioned concepts and abilities that are included in existing definitions of information literacy. This result suggests that respondents may possess an informal version of information literacy, even though they are unaware of its formal counterpart. The unfamiliarity of geographic information users with the formal term information literacy is a concern. Information literacy is emerging as an essential survival skill for the information-based economy. Concepts and abilities relevant to information literacy are applicable to all forms of information, including geographic information (Carter Peoples and Krygier, 2002). Further research on the issue of geographic information users unfamiliarity with general ideas surrounding information literacy will have to part of a broader GIL research agenda.

Responses to the open questions covered a wide range of concepts and abilities. A difficulty with open responses is that respondents had varying methods of expressing similar ideas. To handle variability in open answers the responses were recoded using the general concept classifications used with the closed questionnaire. The grouping process was necessary to analyze the responses. However, a level of detail was lost in this process.

Traditional and digital responses were grouped and compared. Table 4.13 shows the percentage of essential, important or optional for digital or traditional groups.

Concept	Traditional	% Total	Digital	% Total	Total
Essential	**48**	52.7%	**43**	47.2%	*91*
Important	**39**	60.0%	**26**	40.0%	*65*
Optional	**12**	44.4%	**15**	55.6%	*27*
Total	**99**	54.1%	**84**	45.9%	*183*

Table 4.13: Open Question Responses

Traditional geographic information responses ranked as essential accounted for 53% of the essential responses and 60% of the important responses. Traditional geographic information concepts had a greater percentage than the digital geographic information in all of the categories except the optional grouping. In the optional grouping, digital geographic information concepts and abilities were ranked higher than traditional geographic information concepts and abilities by 11%. The open responses suggest geographic information users believe both traditional and digital geographic information concepts and abilities are an important part of geographic information literacy. This result is similar to the results in Part One of the questionnaire; traditional geographic information has a firm base of support as an essential component of K-12 education. Yet, results suggest digital geographic information concepts and abilities are gaining acceptance as important knowledge for K-12 students. Chi-square analysis of the results from the open questions was carried out. The null hypothesis tested is that no relationship exists between respondents and how they value traditional and digital geographic information concepts and abilities. The calculated Chi-square was 1.99, but was not significant at a ninety-five percent confidence interval. Hence the null hypothesis may not be rejected. The following sections summarize the results of the traditional and digital geographic information open responses.

4.7 Traditional Geographic Information Open Responses

Within the open responses, map reading and understanding was the most frequently mention concept. It accounted for twenty-one or (48%) of the essential responses within the traditional geographic information category. The category of map reading and understanding includes items such as: using thematic and topographic maps, locating features on a map; and understanding symbols used on a map. Table 4.14 characterizes the essential responses for this section.

Concepts	Responses
Map Reading and Understanding	21
Scale	8
Directions	6
Symbols and Legends	6
Map Projections	3
Co-ordinate Systems	2
Distance	2
Total	**48**

Table 4.14: Breakdown of Essential Traditional Geographic Information Open Responses

The essential traditional geographic information concepts and abilities given in the open responses were similar to the responses given in Part One of the questionnaire. Concepts such as map reading and understanding, scale and direction were highly rated in both parts of the questionnaire.

4.8 Digital Geographic Information Concepts and Abilities

No dominant essential digital geographic information concept or ability emerged within the digital geographic information open responses. Table 4.15 provides a breakdown of the open digital geographic information responses. In the open responses, non-spatial database design was the most frequent concept or ability. Non-spatial database design includes the knowledge necessary to design and populate an attribute database. An essential rating for non-spatial data design and spatial data organization contradicts the results from Part One of the questionnaire. In the closed questions, technical concepts and abilities did not receive essential ratings. Of note amongst the open results is an essential rating for geographic information management. Within the closed questionnaire the ability to locate geographic information via the Internet was the only digital geographic information concept and ability ranked as essential. The ability to locate geographic information via the Internet is an element of geographic information management.

Concepts	**Responses**
Non-Spatial Data Design	15
Geographic Information Management	13
Spatial Data Organization	6
Attribute Information	6
Metadata	3
Total	**43**

Table 4.15: Digital Geographic Information Open Results

Within the digital open responses, there was crossover with traditional geographic information concepts and abilities. This crossover is, in part, due to the definitions of digital and traditional geographic information used when creating the questionnaire.

Respondents will have varying ideas about what constitutes traditional and digital geographic information based on their personal education and experiences with geographic information. Traditional concepts and abilities such as scale, and co-ordinate systems, for instance, received mentions as essential or important digital geographic concepts.

In the digital environment traditional concepts and abilities have developed a different meaning (Goodchild and Proctor, 1997). Scale, for instance, has been expressed as a comparison between a distance on a map and the distance on the ground. Conversely, in the digital world no equivalent of map distance exists, therefore making the measure un-definable (Goodchild and Proctor, 1997). Traditional descriptors, such as scale, bridge the divide between old and new technologies, allowing a new user an opportunity to become comfortable with digital technologies (Goodchild and Proctor, 1997).

4.9 Assessment of Methodology

The majority of questionnaire respondents were from an educational background. The questionnaire methodology failed to bring in the opinions of the Geomatics industry concerning GIL at the K-12 level. A majority of questionnaire respondents were from education. The results of the questionnaire demonstrate that respondents are secure in their knowledge of traditional forms of geographic information, and that respondents are not as aware of digital geographic information. The absence of highly ranked digital geographic information concepts also symbolizes the opinions of respondents' familiar with the K-12 system, and hence only included concepts and abilities that are presently appropriate for the K-12 level. Also, it could be argued that a number of the digital geographic information concepts listed in the questionnaire were too complex for students at the K-12 level.

In contrast, opinions of the Geomatics industry were not apparent in the questionnaire results. Only ten percent of total responses were from industry. Yet, recent reports commissioned by the Geomatics industry show that the Geomatics industry believes strongly in teaching students about traditional and digital geographic information at the K-12 level. The Geomatics Sector Human Resources Study (2001) recommended that students in K-12 should be exposed to digital and traditional forms of geographic information in the course of their K-12 education. The report recognized that the manner in which students are being taught about geographic information at the K-12 level, impacts on how they are taught at the post-secondary level.

The low response rate from the Geomatics industry is in part due to the manner in which the questionnaire was promoted and designed. The list-servers used to promote the questionnaire belonged primarily to educational organizations and to a lesser extent industry. Greater attention should have been taken to design and promote the questionnaire in a way that appealed to members of the Geomatics industry. If more members from the Geomatics industry had completed the questionnaire, it can be argued that digital geographic information concepts and abilities might have received a higher ranking in the results. This limitation should be addressed in future research.

4.10 Conclusions

The results of the online questionnaire were used to address the three research questions for this chapter. Geographic information users answering this questionnaire ranked the traditional geographic information concepts and abilities higher than digital geographic information concepts. Respondents also felt both types of geographic information are important for K-12 students. Examination of these results showed that geographic information users were confident about which traditional geographic information concepts and abilities should be taught at the K-12 level. The same respondents did not have the same confidence for digital geographic information concepts. None of the four demographic factors used in the analysis revealed a statistically significant relationship between demography and respondents ratings of traditional and digital geographic information concepts.

5. CONTENT ANALYSIS OF THE BRITISH COLUMBIA CURRICULUM

5.1 Introduction

This chapter examines how geographic information literacy, as defined by geographic information users is handled in portions of British Columbia's current K-12 curriculum. The foundation for the content analysis is the results of the online questionnaire summarized in chapter four. Section 5.2 describes how essential and important responses from the closed portion of the online questionnaire were synthesized into a geographic information literacy-coding frame. Section 5.3 briefly introduces the curriculum materials targeted for this content analysis. Portions of these current British Columbia K-12 curricula were analyzed using the content analysis software NUD*IST® 5, section 5.4 describes how the software was used in this research. The results of the content analysis are reported in sections 5.5 and 5.6.

Ontario's geomatics course (CGO4M) was analyzed for geographic information literacy content using the coding frame described in section 5.2. The province has been identified as the national leader in geographic education and in the usage of digital geographic information at the K-12 level of education. Ontario's geomatics course was selected for analysis because it is the only course of its type in Canada. Section 5.7 illustrates how geographic information literacy is represented within the CGO4M curriculum and provides comparisons with the results from British Columbia. Section 5.8 assesses the methodology employed in this chapter.

5.2 Geographic Information Literacy Coding Frame

Results of the closed questions of the online questionnaire, previously reported in Section 4.3 formed the foundation for a geographic information literacy-coding frame. The coding frame consisted of three topic areas:

- traditional geographic information;
- digital geographic information; and
- information literacy.

These topics area are consistent with those used in the analysis of the questionnaire in Chapter Four. Concepts and abilities ranked as essential and important (questions with a mode of three or two in Section 4.3) were placed into one of the three above mentioned topics areas and simplified into key words. The keywords summarize the concept or abilities discussed within the question.

For example, question one, the highest-ranking question in the questionnaire was *Understand how to state scale in its various formats.* The question was subsequently separated into the keywords: scale, representative fraction, verbal scale, and visual scale. A search for key words related to scale thereby located occurrences of scale and the various forms of scale used to represent geographic information. The results of this coding process are summarized in Table 5.1. The table contains all of the geographic information literacy keywords and phrases used in the content analysis.

Traditional Geographic Information	Digital Geographic Information	Information Literacy
Distance	Internet Searches	Quantitative
Calculate distances	Resolution	Qualitative
Calculate area	Level of Detail	Charts
Scale	Digital Maps	Graphs
Representative fraction	Metadata	Primary information
Verbal Scale	Coordinate system	Secondary information
Visual Scale	Projection	Units of measurement
Map Reading	Horizontal datum	Errors propagation
Visual patterns	Vertical datum	Accuracy
Topographic map	Geo-reference	Precision
Metadata	Scanning	Levels of measurement
Map projection	Digitizing	Mode
Height	Digitizing errors	Mean
Elevations	Attribute database	Median
Contours	Selecting analysis	Absolute data
Symbols	Buffer	Derived data
Thematic map	Geo-technologies	Information
Map production and design	Limitations of technology	Currency
Visual patterns	Copyright issues	Completeness
Library search	Ethical issues	Cost
Location	Legal issues	
Latitude/Longitude	Socio-economic issues	
Cartesian grid	Global Positioning	
Cardinal directions	Systems	
Bearing		
True north,		
Magnetic north		
Grid north		
Compass		
Elevations		
Contours		

Table 5.1: Geographic Information Literacy Keywords and Phrases Derived from Online Questionnaire Results

While constructing the coding frame, synonyms of key terms were included. For example, when searching for occurrences of digital geographic information usage in the curriculum it was necessary to search for the term geo-technology. Geo-technologies refer to technologies used to access geographic information. However, the term geo-technology was not found in early pilots of the content analysis. The term is an industry term that might not be familiar to those outside of this professional group. Educators would have greater familiarity with specific forms of geo-technologies (e.g. Remote Sensing, and GIS). To compensate, searches were also conducted using the terms Remote Sensing and GIS. Any occurrences of the two terms found in the content analysis are reported under geo-technologies. Also, it was necessary to simplify a complex concept or ability down to its core concepts. For example, to understand raster and vector data models, two common techniques for representing space, it is necessary to have an understanding of concepts such as grids and Cartesian Co-ordinates. The terms grids and Cartesian Co-ordinates were included in the content analysis.

5.3 Integrated Resource Documents (IRP)

With a coding frame in place, the focus of the analysis moved to locating and preparing source materials for the content analysis. The source documents for the content analysis were the Integrated Resource Packages (IRP). The IRP's provide teachers with a guide for teaching a subject in the province of British Columbia and consist of: prescribed learning outcomes for specific grade levels, suggested instructional strategies and assessments, and recommended resources. These documents are vehicles for teaching sets of knowledge, skills and attributes (Ministry of Education, 2000). These documents provide teachers with the basic information to implement a course at a specified grade level (Ministry of Education, 2003).

The documents have three parts:

- Introduction;
- Curriculum; and
- Appendix.

Only the curriculum portion of the document was analyzed for the content analysis. The decision to analyze only the curriculum portion of the IRP was to focus the research on the curriculum and the learning outcomes teachers' use in their classroom. The digital versions of the IRP's were obtained from British Columbia's Ministry of Education website (www.bced.gov.bc.ca/irp). Five subject areas were selected because of their potential relevancy to geographic information literacy. Table 5.2 specifies the subject areas and grade levels examined in the content analysis.

Subject	**Grade Levels**
Social Studies	2-11
Geography and Earth Science	12
Information Technology	8-12
Mathematics	2-12
Science	K-10

Table 5.2: Selected Subject Areas for the Content Analysis

The inter-disciplinary nature of geography suggests that geographic information literacy is grounded in subject areas such as social studies, geography and earth science, but its also utilizes knowledge from science, mathematics, and information technology. The curricula from science and mathematics were included to see what degree of geographic information literacy is present in these subject areas. Using maps to calculate values such as area and converting between different units of measure, are examples of concepts and abilities associated with these curricula that scored highly in the questionnaire. It is also necessary to include concepts and abilities related to information technology. Concepts and abilities taught as part of information technology curricula teach students to access and utilize all forms of digital information. Being able to locate geographic information on the Internet was ranked as an essential concept in the online questionnaire. By grade twelve a student is expected to be literate in a variety of hardware and software, as well as have a basic understanding of how to use technology as an analytical tool and how it can impact society (Ministry of Education, 2001). It is a combination of subject areas that will provide students with the knowledge necessary to be comfortable with geographic information in a digital environment.

5.4 Content Analysis with NUD*IST® 5

The NUD*IST® software was used to search the digital curriculum documents for geographic information literacy content. The selected portions of the IRP documents were separated by grade level and saved as text files. The conversion to text file was necessary to accommodate the NUD*IST® software which only imports files stored as text files. Dividing curriculum documents by grade level also allowed for a detailed comparison of GIL content by grade level.

Following the file conversion process the individual keywords (Table 5.1) were each entered into the NUD*IST® program. Using the text search option, the NUD*IST® software simultaneously searched all of the selected curricula by grade level for the presence of each keyword.. The result of each text search was a report describing how many times a keyword or phrase occurred in each file. The results of each report are summarized in the following sections. Section 5.5 summarizes the results based on topic area (traditional geographic information, digital geographic information, information literacy).

5.5 Content Analysis Results by Topic Area

Table 5.3 demonstrates a lack of digital geographic information content in the selected IRP documents. In total there were 1,267 GIL keywords or phrases from Table 5.1 found in the selected IRP documents.

Grouping	Keyword Occurrences	% Total
Traditional Geographic Information	721	56.9
Digital Geographic Information	73	5.8
Information Literacy	473	37.3
Total	1267	100

Table 5.3: Breakdown of GIL Keyword Occurrences by Topic Area

Outside of the category of digital geographic information, the searched portions of the current curriculum cover traditional geographic information and information literacy in greater depth. Greater than half (56.9%) of the GIL keywords found through the content analysis belonged to traditional geographic information. The curricula analyzed contained the concepts and abilities identified as necessary to use traditional forms of geographic information (i.e. paper maps, atlases and globes). For information literacy, the results suggest the curriculum is providing students with some of the concepts and abilities necessary to be information literate. A third of the total keywords found (37.3%) belonged to information literacy. These results suggest that concepts and abilities related to traditional geographic information and information literacy are present at the K-12 level. This is not the situation with digital geographic information. Noticeably only 5.8 % of the keyword occurrences found could be classed as relating to digital geographic information. These incidences of digital geographic information content were found primarily in the social studies and geography curricula. These occurrences primarily involved the usage of geo-technologies such as GIS, remote sensing and GPS to examine geographic issues. This result suggests that currently digital geographic information has a limited profile at the K-12 level. Additional research of the issue is necessary to raise the profile of digital geographic information among educators. Educators need to be made aware of the educational possibilities for digital geographic information within the social studies and geography curricula, and that it can also be used with mathematics and science curricula.

5.6 Content Analysis by Subject Area

The results of the content analysis were analyzed by subject areas to illustrate how GIL is represented throughout the K-12 curriculum. Table 5.4 illustrates the breakdown of the 1267 keywords by subject area. The breakdown is balanced among all subjects, except information technology. These results demonstrate that geographic information literacy is not the exclusive domain of geography and social studies. Figures 5.1(a,b,c,d) illustrate how the occurrences of GIL keywords break down by grade and subject area. Of note in Figure 5.1 (a,b,c,d) is the rise in occurrences of GIL content at higher grade levels. The increase at the higher grades especially pronounced in the social studies and mathematics curricula.

Subject	Number of Occurrences of Keywords
Social Studies*	410
Information Technology	59
Mathematics	550
Science	248

*includes geography 12 and earth science 12

Table 5.4: GIL Keyword Findings by Subject Area

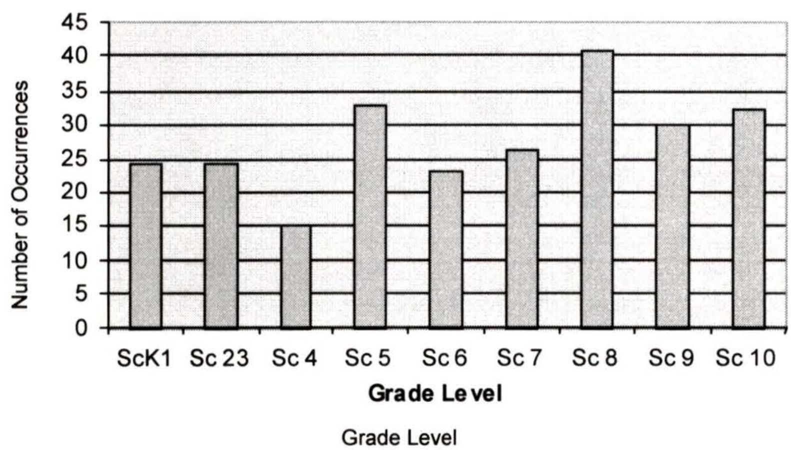


Figure 5.1a: Breakdown of Content Analysis by Grade Level and Subject Area (Science K-10)

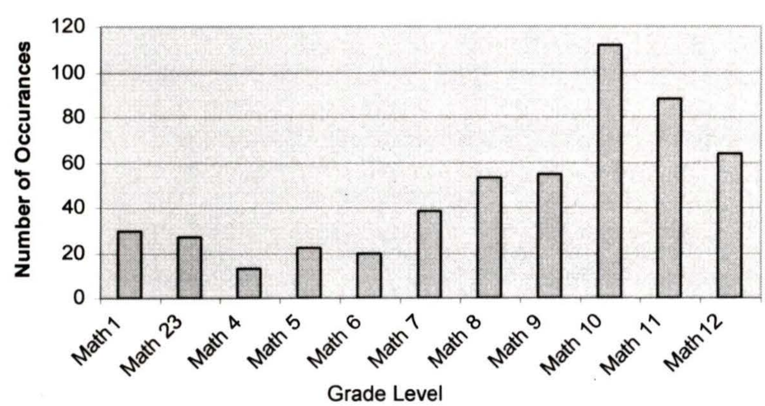


Figure 5.1b: Breakdown of Content Analysis by Grade Level and Subject Area (Math K-12)

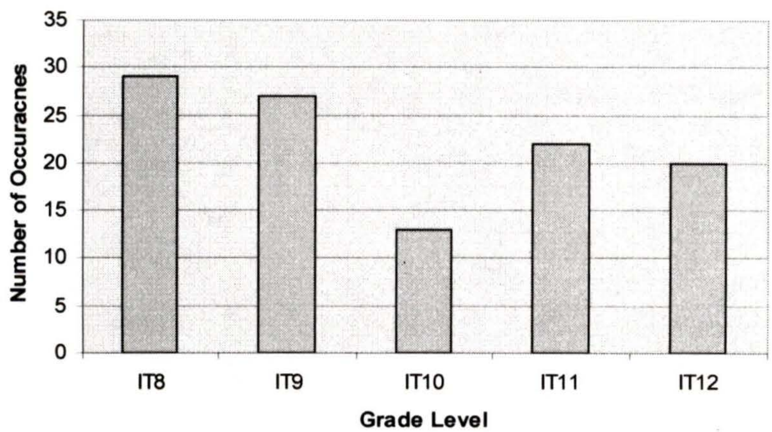


Figure 5.1c: Breakdown of Content Analysis by Grade Level and Subject Area (Information Technology 8-12)

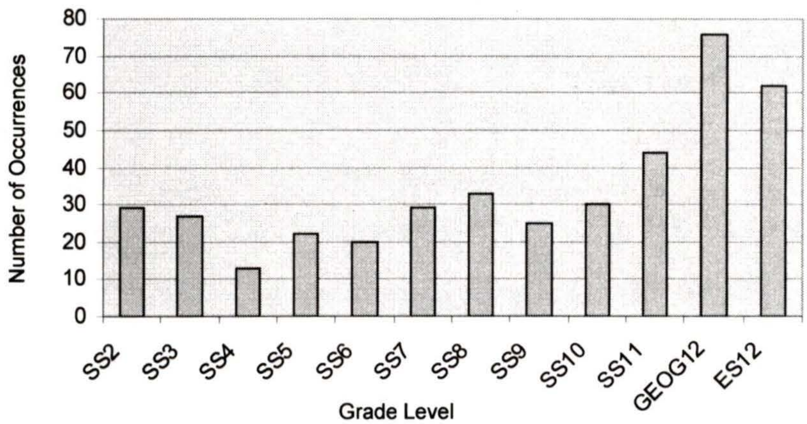


Figure 5.1d: Breakdown of Content Analysis by Grade Level and Subject Area (Geography and Social Studies K-12)

The limited presence of geographic information literacy in the curriculum documents for courses at higher grades suggests that any effort to build geographic information literacy at the K-12 level will have to focus on the secondary education system, between grades eight and twelve. Prior to the secondary school, students do not receive sufficient exposure to material related to GIL. Further research on GIL at the K-7 level is necessary to determine which attributes of GIL are appropriate for this grade range.

5.6.1 Social Studies, Geography and Earth Science

Tables 5.5, 5.6 and 5.7 show how the three topic areas of geographic information literacy are represented in the social studies curriculum. The Social Studies curriculum (2-11 Geography 12 and Earth Science 12) only make passing reference to digital geographic information through the mention of geo-technologies. The selected IRP documents mention digital geographic information in the context of:

> *" using current technologies to address relevant geographic issues".*
>
> (Ministry of Education, 1998: 12)

The selected IRP's refer to geo-technologies such as GIS, Remote Sensing and GPS. These technologies were mentioned within IRP's for Social Studies 11, Earth Science 12 and Geography 12.

Social Studies curriculum documents fail to address items such as: *Interne*t or *Web-Based Maps*. These documents also fail to make any specific mention of digital geographic information and how it is linked to other issues, such as the role of the Internet and the proper usage of the information. The results of the online questionnaire in Chapter Four showed that knowing what to look for when searching for geographic information is an essential part of K-12 geographic information literacy.

Concept or ability	**SS 2-3**	**SS 4**	**SS 5**	**SS 6**	**SS 7**	**SS 8**	**SS 9**	**SS 10**	**SS 11**	**GE 12**	**ES 12**	**Total**
scale	1	1	1	1	4	2	1	1		2	8	22
verbal scale					1							1
visual scale					1							1
representative fraction												0
distance			2			2				2	10	16
UTM												0
Latitude/longitude			2	2			1				1	6
location	12	1	2	2	7	5	3	2	4	22	11	71
symbols	33	3				1		1		2		40
direction	6					1	1	1		4	3	16
grid.		2	2			1	1	1		1		8
topographic map			1							5		6
Identifying patterns				7	5	5	2	5	5	6	5	40
contours.						1	1	1		1		4
thematic map			1				2					3
compass										1		1
magnetic north												0
grid north												0
true north												0
height											1	1
map projections												0
metadata												0
calculate area												0
Legends		3		1	2	1	1	1				9
Occurrences By Grade	**27**	**9**	**9**	**12**	**14**	**17**	**12**	**12**	**9**	**44**	**31**	221

Table 5.5: Breakdown of Traditional Geographic Information within the Social Studies Curriculum

Concept or Ability	SS 2-3	SS 4	SS 5	SS 6	SS 7	SS 8	SS 9	SS 10	SS 11	GE 12	ES 12	Total
internet search							1	3	1	2		7
resolution												0
digital map												0
geo-technologies usage									5	1	2	8
copyright issues												0
limitations of geographic information												0
GPS									1			1
ethical, legal and socio-economic issues surrounding geographic information												0
geo-referencing												0
scanning												0
spatial data organization												0
spatial reference information												0
projection												0
coordinate system			1				1				1	3
design database.								1		1	2	4
buffering												0
Occurrences by Grade	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**4**	**7**	**4**	**5**	23

Table 5.6: Breakdown of Digital Geographic Information within the Social Studies Curriculum

Concept or ability	SS 2-3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	SS11	GE 12	ES 12	Total
quantitative												0
qualitative												0
charts and graphs	1		2		4			4	2	6	4	23
secondary information			1		1	3	2	1	3			11
primary information.			1	1	1	3		1	3			10
unit conversion												0
errors												0
precision												0
accurate	3	4	4	5	7	5	6	5	6	12	2	59
accuracy			1	1	1	4		2	5	2	13	29
levels of measurement.												0
statistics									3			3
information currency			2	1		1	2		2	5		13
information cost.												0
information completeness											1	1
data manipulation											1	1
analysis methods			1		1		1	1	4	3	5	16
Occurrences by Grade	**4**	**4**	**12**	**8**	**15**	**16**	**11**	**14**	**28**	**28**	**26**	**166**

Table 5.7: Breakdown of Information Literacy Content within the Social Studies Curriculum.

Social studies curricula contain a basic set of concepts and abilities to educate students about geographic information (Chapin and Messick, 2002; Obenhaus, 1990; Wiegand, 1998). These concepts and abilities include: scale, symbols, and legends. These basic concepts and abilities are well covered throughout the selected portions of the curriculum. Outside of these basic concepts, however, there is a level of disagreement between the questionnaire respondents and the curriculum developers about which GIL concepts and abilities are appropriate for various grade levels. Table 5.5 illustrates how these traditional geographic information concepts are represented in the social studies curriculum. Several essential traditional geographic information concepts and abilities were not located in the content analysis. This result suggests that a number of concepts and abilities listed as essential by questionnaire respondents might be inappropriate for the K-12 students. Yet, there are concepts that had zero responses in the content analysis, which are suitable for K-12 students. Map projections, for example are considered to be appropriate topics for students at higher grade levels (10-12), but the concept is not addressed in the reviewed curriculum documents (Singer, 1997). Also concepts and abilities with zero responses in social studies curriculum are addressed in the curriculums documents for other subjects, such as mathematics and science.

5.6.2 Mathematics and Science

Mathematics and science are core subjects within the overall education curriculum (American Association for the Advancement of Science, 2000). The materials covered in these two subjects serve as a foundation for material covered in other areas. A geographic information literate individual uses concepts and abilities covered within these subjects to enhance their overall understanding of geographic information.

To illustrate the importance of science and mathematics to geographic information literacy, the curricula for both subjects were reviewed for geographic information literacy content. The Science K-10 and Mathematics K-12 IRP documents were analyzed by grade level and the results of the analysis are summarized in Table 5.8. Results of content analysis on the science curriculum are shown in Tables 5.9 (a, b, c).

The results of the content analysis on the mathematics curriculum are shown in Tables 5.10 (a, b).

Area	Science K-10	Math K-12	Total
Traditional Geographic Information	208	277	485
Digital Geographic Information	5	10	15
Information Literacy	35	263	298
Total	**248**	**550**	**798**

Table 5.8: Results of Science and Mathematics Content Analysis

The results of content analysis indicate a presence for traditional geographic information and information literacy content within the science and mathematics curricula. However the content found in both of the information literacy and traditional geographic information groupings tends to deal with general concepts and abilities. For example;

- Scale
- Location
- Symbology
- Pattern analysis
- Errors
- Accuracy
- Precision
- Calculating Area

These curricula also include several of the overlooked concepts and abilities from the analysis of the social studies curriculum in the section 5.6.1. Concepts such as calculating area and bearings, for instance are addressed in the math and science curricula.

The presence of the traditional geographic information and general information concepts in the mathematics and science curricula is important as they help to reinforce the social studies curricula. Their presence indicates that students are reinforcing and developing knowledge that contributes to their geographic information literacy from outside traditional sources such as social studies. The inclusion of geographic information literacy concepts within science and mathematics curricula provide students with an added context to develop their understanding of geographic information. Applying an interdisciplinary approach to geographic information literacy provides students with a variety of perspectives provided by different subject areas and helps students to understand what they are learning. Focusing attention on geography's connections to mathematics and science is one way to raise the profile of geography. Geography is constantly fighting for attention with other subjects, such as history, for space within the curriculum (Semple, 2001).

There is little or no digital geographic information within the reviewed mathematics or science curricula. Only fifteen of the seven-hundred and ninety keyword occurrences for science and mathematics were from the digital geographic information group. This further supports the previous observation with social studies and information technology curricula that digital geographic information is not well represented within the current K-12 curriculum.

	Grades								
Concept or Ability	**Sc 23**	**Sc 4**	**Sc 5**	**Sc 6**	**Sc 7**	**Sc 8**	**Sc 9**	**Sc 10**	**Total**
Internet search						3	1	1	5
Resolution									
Digital map									
Geo-technologies usage									
Copyright issues									
Limitations of geographic information									
GPS									
Ethical, legal and socio-economic issues surrounding geographic information									
Geo-referencing									
Scanning									
Spatial data organization									
Spatial reference information									
Projection									
Coordinate system									
Design database.									
Buffering									
Total						**3**	**1**	**1**	**5**

Table 5.9a: Results of Digital Geographic Information Content Analysis on K-10 Science Curriculum.

	Grades									
Concept or Ability	**Sc 1**	**Sc 23**	**Sc 4**	**Sc 5**	**Sc 6**	**Sc 7**	**Sc 8**	**Sc 9**	**Sc 10**	**Total**
Scale		2		1	1		1	2		7
Distance					1	3		5	2	11
UTM										
Latitude/ Longitude										
Location			2	1		1		1	1	6
Symbols	2						5		3	10
Direction					5			2		7
Grid.										
Topographic map						2				2
Identifying patterns	19	20	8	24	11	14	27	14	17	154
Contours.										
Thematic map										
Compass		2							1	3
Bearing										
Height								1		1
Map Projections										
Metadata										
Calculate area			3	1	3					7
Legends										
Total	**21**	**24**	**13**	**27**	**21**	**20**	**33**	**25**	**24**	**208**

Table 5.9b: Results of Traditional Geographic Information Content Analysis on K-10 Science Curriculum.

	Grades									
Concept or Ability	**Sc 1**	**Sc 23**	**Sc 4**	**Sc 5**	**Sc 6**	**Sc 7**	**Sc 8**	**Sc 9**	**Sc 10**	**Total**
Primary Information.										
Unit conversion										
Errors				1				1		2
Precision				1						1
Accuracy	2			4	2	4	3	2	3	20
Levels of measurement.										
Statistics							1			1
Information Currency										
Information cost.										
Information Completeness										
Data manipulation	1		2				1		3	7
Analysis methods						2		1	1	4
Total	**3**		**2**	**6**	**2**	**6**	**5**	**4**	**7**	**35**

Table 5.9c: Results of Information Literacy Content Analysis on K-10 Science Curriculum

	Grades											
Concept or Ability	**Ma 1**	**Ma 2-3**	**Ma 4**	**Ma 5**	**Ma 6**	**Ma 7**	**Ma 8**	**Ma 9**	**Ma 10**	**Ma 11**	**Ma 12**	**Total**
primary information.												
unit conversion				3	3	4	1	1	2	13	4	31
errors						1	2	6	3	5	5	22
precision					1			1	1	6		9
accuracy		2	5	2	2	4	6	9	12	7	7	56
levels of measurement.												
statistics		4	4	6	5	7	11	20	11	13	15	96
information currency												
information cost.												
information completeness												
data manipulation										1	1	2
analysis methods		5	1	2	1	1	5	4	15	5	8	47
Total		**11**	**10**	**13**	**12**	**17**	**25**	**41**	**44**	**50**	**40**	**263**

Table 5.10a: Breakdown of Information Literacy within the Mathematics K-12 Curriculum.

Concept or Ability	Grades											Total
	Ma 1	**Ma 2-3**	**Ma 4**	**Ma 5**	**Ma 6**	**Ma 7**	**Ma 8**	**Ma 9**	**Ma 10**	**Ma 11**	**Ma 12**	
scale		1	2	1	3	1	7		20	13		48
distance							1	1	4	3	1	10
UTM												
latitude/longitude												
location		2				1				4	1	8
symbols		4	6			3				1	1	15
direction												
grid.			5	8	4	1	1			2	1	22
topographic map												
identifying patterns												
contours.												
thematic map												
compass												
Bearing									2			2
height												
map projections												
metadata												
calculate area		6	10	18	24	15	19	13	32	15	20	172
legends												
Total		**13**	**23**	**27**	**31**	**21**	**28**	**14**	**58**	**38**	**24**	**277**

Table 5.10b: Breakdown of Traditional Geographic information within the Mathematics Curriculum

5.6.3 Information Technology

Information technologies, along with social studies, are likely places within the curriculum to find geographic information literacy content. However, based on the content analysis, the information technology curriculum was the least likely place to find geographic information literacy content. Only 59 of the 1267 total GIL occurrences (4.6%) were found in information technology curricula. Tables 5.11 (a,b,c) show where these occurrences occur within the curriculum.

The information technology curriculum for grades eight through twelve makes mention of using digital information and providing students with the necessary tools to use it (Ministry of Education, 1999). The curriculum provides students with the necessary knowledge to be successful in the information age. The information technology curriculum touches upon the following issues:

- the role of the Internet in society;
- utilizing electronic sources of information (i.e. paying attention to copyright when using these sources); and
- issues surrounding the creation of digital media video, audio and text. (i.e. usage of scanners and digital camera)

Along similar lines, digital audio, video and text are used to communicate digital geographic information. Web-based maps, for instance, make use of all three forms of media to enrich the usage of geographic information (van Elzakker, 2001; Asche, 1998; Peterson, 1997).

	Grades					
Concept or Ability	**8**	**9**	**10**	**11**	**12**	**Total**
internet search	4	6	7	5	4	26
resolution						
digital map						
geo-technologies usage						
copyright issues		2	1	2	1	6
limitations of GI						
GPS						
ethical, legal and socio-economic						
geo-referencing						
scanning				1		1
spatial data organization						
spatial reference information						
projection						
coordinate system						
design database.		1			1	2
buffering						
Total	**4**	**9**	**8**	**8**	**6**	**35**

Table 5.11a: Breakdown of Digital Geographic Information Content within the 8-12 Information Technology Curriculum

	Grade					
Concept or ability	**8**	**9**	**10**	**11**	**12**	**Total**
quantitative						
qualitative						
charts and graphs						
secondary information						
primary information.		1				1
unit conversion						
errors				1	1	2
precision						
accurate						
accuracy						
levels of measurement.						
statistics						
information currency	1					2
information cost.						
information completeness						
data manipulatior			2			2
analysis methods		1		2		3
Occurrences	**1**	**2**	**2**	**3**	**1**	**10**

Table 5.11b: Breakdown of Information Literacy Content within the 8-12 information technology curriculum.

	Grade					
Concept or Ability	**8**	**9**	**10**	**11**	**12**	**Total**
scale						
verbal scale						
visual scale						
representative fraction						
distance						
UTM						
latitude/longitude						
location	1	2	5	3	2	13
symbols						
direction						
grid.						
topographic map						
identifying patterns	1					1
contours.						
thematic map						
compass						
magnetic north						
grid north						
true north						
height						
map projections						
metadata						
calculate area						
legends	1					1
Occurrences	**3**	**2**	**5**	**3**	**2**	**15**

Table 5.11c: Breakdown of Traditional Geographic Information Content within the 8-12 Information Technology Curriculum

5.7 Ontario and Geographic Information Literacy

The results of the content analysis in Section 5.6, points to a lack of digital geographic information content within related subject areas from the British Columbia curriculum. The lack of digital geographic information content in areas such as social studies may be a symptomatic of an overall lack of geographic education within the provinces K-12 curriculum. The Province of Ontario, in contrast has realized the importance of K-12 geographic education, and has integrated geographic education into all levels of its social studies curriculum. The Province of Ontario has also worked to include digital geographic information in its geography curriculum (Sharpe and Creciollo Best, 2001). Ontario leads the country in including digital geographic information and geo-technologies (i.e. GIS, Remote Sensing and GPS) in their curriculum. It was also the first province to secure a licensing agreement with the GIS software manufacturer (ESRI) for the Arc View software (ESRI, 2001). Ontario is the only province currently offering a course in Geomatics at the K-12 level. The course CGO4M "Geomatics in Action" is University/ College preparation course offered in grade 12. A Preparation course is designed to equip students with the knowledge and skills they need to meet the expectations of university and college level courses. The Ontario Ministry of Education describes the course as follows:

> *"Geomatics: Geo-technologies in Action examines the approaches and techniques that geographers and other professionals use to acquire, manage, map, analyse, and communicate information about the earth's surface. Students will receive a systematic introduction to the four pillars of Geomatics - surveying, remote sensing, cartography, and geographic information systems (GIS), and will learn how to apply their knowledge and skills to a variety of real world situations relating to physical and human geography.*
>
> *(Catholic District School Board Writing Partnership, 2002: 1)*

In order to assess geographic information literacy within Ontario's K-12 curriculum, the CG04M "Geomatics in Action" course profile was analyzed by employing the same methodology used to evaluate British Columbia's K-12 curriculum. Course profiles are professional development materials designed to help teachers implement new courses within the grade 12 secondary school curriculum. The creation of course profiles is funded by Ontario's Ministry of Education, and the documents are designed by schools boards with assistance from local subject associations (Catholic District School Board Writing Partnership, 2002). These documents are similar in nature to the IRP documents used in British Columbia.

A detailed account of which concepts and abilities were found within the CGO4M course profile through the content analysis can be found in Table 5.13. The results of the content analysis suggest the course profile for CGO4M equally represents the three components of geographic information literacy as expressed by geographic information users via the questionnaire. As a percentage of the total findings of geographic information literacy (429), there is greater equality between the three classes than with any portion of the analyzed British Columbia curricula.

Traditional Geographic Information			Digital Geographic Information			Information Literacy	
Concept or Ability	**CG04M**		**CONCEPT OR ABILITY**	**CG04M**		**Concept or Ability**	**CG04M**
scale	8		internet search	44		primary information.	0
distance	4		resolution	2		unit conversion	0
UTM	1		digital map	0		errors	0
latitude/longitude	1		geo-technologies usage	61		precision	0
location	8		copyright issues	3		accuracy	1
symbols	4		limitations of geographic information	15		levels of measurement.	0
direction	4		GPS	18		statistics	13
grid.	2		ethical, legal and socio-economic issues surrounding geographic information	6		information currency	1
topographic map	4		geo-referencing	3		information cost.	2
identifying patterns	65		scanning	1		information completeness	1
contours.	1		spatial data organization	11		data manipulation	3
thematic map	8		spatial reference information	0		analysis methods	76
compass	3		projection	13			
Bearing	1		coordinate system	3			
height			design database.	3			
map projections	13		buffering	1			
metadata	1						
calculate area	16						
legends	4						
Occurrences	**148**		**Occurrences**	**184**		**Occurrences**	**97**

Table 5.12: Breakdown of GIL Content within the CGO4M curriculum (a.) Traditional Geographic Information; (b.) Digital Geographic Information; (c.) Information Literacy

Results from the content analysis of the CGO4M course profiles did not show as much of a disparity between digital geographic information, information literacy and traditional geographic information, as was the case with the analysis of the British Columbia curriculum. The CG04M course was designed to introduce students to traditional techniques for using geographic information, as well as to account for the shift towards digital geographic information (Catholic District School Board Writing Partnership, 2002). The course is well equipped to account for digital geographic information as illustrated by the high number of digital geographic information findings in the content analysis. Of the three geographic information sub-groups, digital geographic information had the highest percentage of total keyword occurrences.

The results of a comparative content analysis between Ontario and British Columbia are summarized in Table 5.12. The CGO4M results were also compared with results from grade 12 courses in geography, earth science, information technology and mathematics. This secondary comparison between only grade 12 courses was done to compare only GIL related material taught at the grade 12 level. Content analysis results comparing CGO4M and selected B.C. curricula and CGO4M and grade 12 courses showed similar results.

Grouping	**BC Curricula**	**BC Grade 12 courses**	**CGO4M**		
Traditional GI	721	101	148		
Digital GI	73	15	184		
Information Literacy	473	95	97		
Total	**1267**	**211**	**429**		
Grouping	**% of Total (1267)**	**% of Total (211)**	**% of Total (429)**	**% Difference (BC – Ont.)**	**% Difference (BC12-Ont)**
Traditional GI	56.9	47.9	34.5	- 15.8	-13.4
Digital GI	5.8	7.1	42.9	+ 36.3	+ 35.9
Information Literacy	37.3	45.0	22.6	- 20.3	-22.4
Total	**100**	**100**	**100**		

Table 5.13: Comparison of Content Analysis between Selected British Columbia Curricula, Grade 12 Courses and the Ontario CGO4M curriculum

The Geomatics CGO4M curriculum therefore appears to be better at representing geographic information literacy than its selected British Columbia counterparts. The combined total for all digital geographic information results within the British Columbia curricula is less than half of that found in the Ontario's Geomatics course. When compared with selected grade 12 courses in British Columbia, the amount of digital geographic information content does not change significantly. The results of the comparative content analysis support the position that geographic information literacy is well represented in Ontario's curriculum when compared to British Columbia.

5.8 Assessment of Methodology

The methodological issues that arose in Chapter Four have had an impact on the results of this chapter. In particular, the lack of collaboration with the geomatics industry suggests an underestimation of the value of digital geographic information to K-12 geographic information literacy. Concepts and abilities relevant to the usage of digital geographic information might have received a higher rating if members of the geomatics industry had participated in the questionnaire, and therefore entered into subsequent analysis in this chapter.

The results of the content analysis in this chapter reveal that digital geographic information is poorly represented in selected portions of British Columbia's current K-12 curriculum. Therefore, it is possible to suggest that students are receiving less exposure to digital geographic information than first suspected or desired. These results also suggest a level of disagreement between questionnaire respondents and curriculum developers about what students need to know about geographic information at the K-12 level. Are essential GIL concepts and abilities missing from the curriculum because they are not appropriate for the K-12 level or are they not included because curriculum designers are unaware of their necessity for a students understanding of geographic information? Consultation with curriculum designers concerning their knowledge of geographic information might help to clarify the disagreement. Also, it is critical to question how well students understand what they are taught about geographic information in the course of their K-12 education. An exit survey of grade twelve students or an examination of provincial exam results might help to assess what students are learning about geographic information over the course of their K-12 education.

5.9 Summary

The results of the online questionnaire were used to analyze selected portions of the K-12 curriculum for geographic information literacy content. Areas of the curriculum were selected for their relevancy to geographic information literacy. The social studies and geography curricula were analyzed for content relevant to geographic information literacy; these documents were examined for specific content relating to usage and understanding geographic information. Mathematics, science and information technology curricula were analyzed to determine if and how geographic information literacy is represented in the curricula of these subject areas.

The content analysis of selected portions of the current K-12 curriculum exposes a lack of digital geographic information content within the curriculum. Conversely, traditional geographic information and information literacy are well represented throughout selected portions of the curriculum. As a means of comparison, the curriculum for the Geomatics 12 courses for Ontario was subjected to the same content analysis as was used with British Columbia curriculum. When compared, the Geomatics curriculum within Ontario better characterizes all three components of geographic information literacy, as expressed by geographic information users.

6. THE FUTURE OF GEOGRAPHIC INFORMATION LITERACY AT THE K-12 LEVEL

6.1 Introduction

Chapter Six explores the future of K-12 geographic information literacy and discusses what additional steps are necessary to further geographic information literacy in the K-12 schools. Sections 6.2 and 6.3 discuss the need for a higher profile of geography within the K-12 curriculum and the need for improved professional development of pre-service and in-service teachers in the subject area. Section 6.4 argues that geography departments at the post secondary level need to do a more efficient job of promoting geography at the K-12 level. Section 6.5 suggests the use of teacher workshops as a technique for introducing teachers to new methods of teaching geography. Section 6.6 reports on a geographic information teacher workshop held at the University of Victoria.

6.2 The Place of Geography

The discussion of research conducted to this point has focused on geographic information users and which concepts and abilities they believe constitute K-12 geographic information literacy. Also discussed was how the opinions of geographic information users are represented in British Columbia's K-12 curriculum. The results of the content analysis indicate that concepts and abilities related to digital geographic information are under-represented within the provincial curricula, while concepts and abilities relating to traditional geographic information and information literacy appear to be reasonably represented in the curriculum. Figure 6.1 outlines the progression of the research to this point.

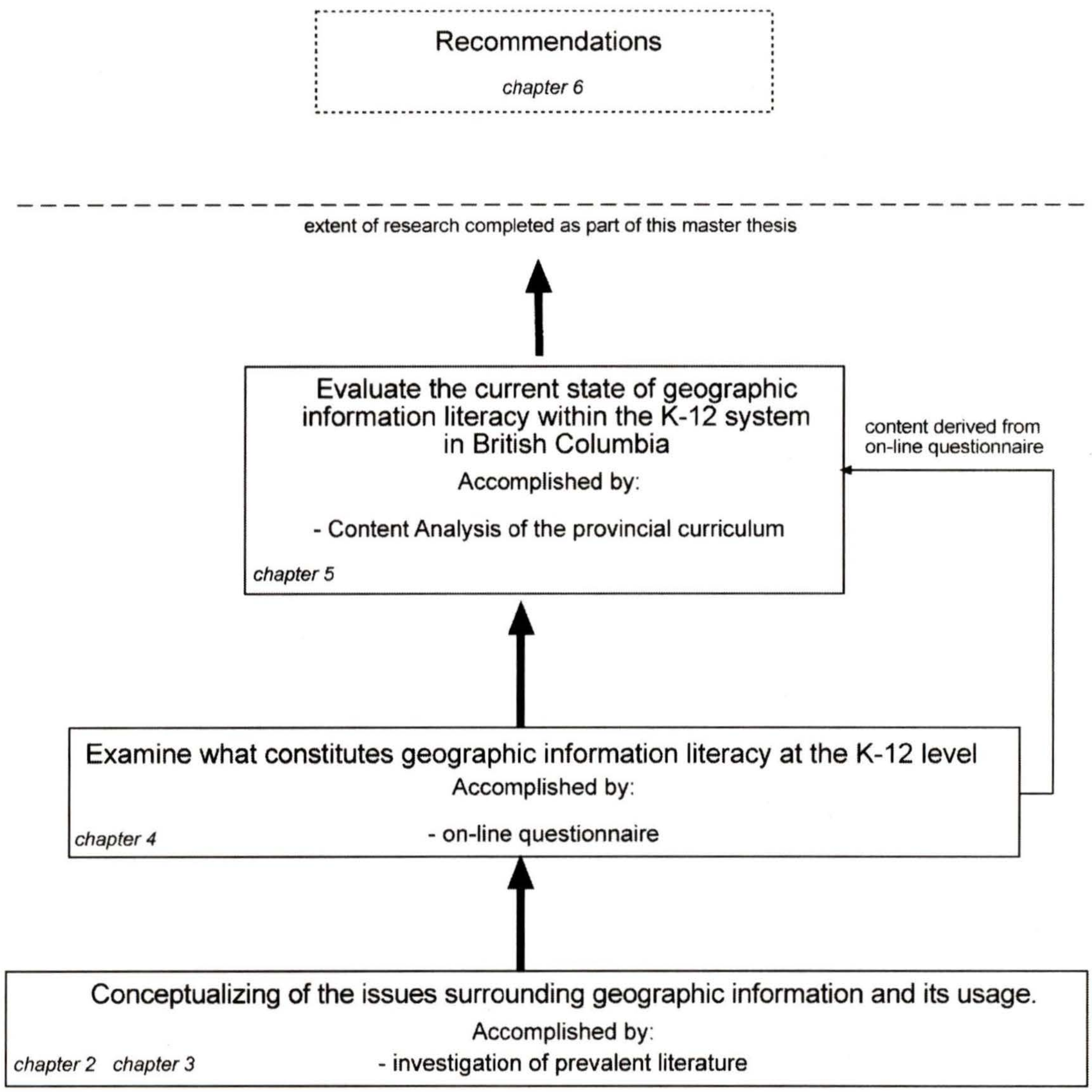


Figure 6.1: Progression of Research Agenda

Digital geographic information is becoming the predominant format for accessing and storing geographic information. The Internet has helped to expose a larger audience to geographic information (Crampton, 1998; Peterson, 1997). Users of geographic information now search the Internet through online databases for geographic information to satisfy needs and to solve problems. In part one of the online questionnaire, geographic information users indicated that searching for geographic information on the Internet was the most essential digital geographic information concept to be taught to students. Traditional geographic information products such as paper maps, atlases and globes, are still significant sources for geographic information, but more people are being exposed to geographic information through digital media (Crampton, 1998).

Recent news coverage of the war on Iraq demonstrates how the public has begun to rely on digital geographic information. Historically, events such as war have forced new technologies into operation (Clarke, 1992). Satellite images provided by the company Digital Globe® portrayed the landscape of major cities such as Baghdad (Associated Press, 2003). News organizations provided interactive maps of the conflict to give the public a sense of how the war was unfolding and to explain the geography of Iraq. The public therefore must be educated in how to use and read digitally derived geographic information products. The role of the education system in an information-based economy should be to provide students with a level of geographic information literacy. However, any effort to improve the profile of K-12 geographic information literacy will not occur until there is an increase in the amount of geographic education within the K-12 curriculum.

Renewed interest in geographic education within the social studies curriculum is a shift away from a social studies curricula influenced by history (Palladino, 1993). Historians have had success in promoting the need for history at the K-12 level (Gilsbach, 1997; Semple, 2001). Geographers need to do a better job of promoting the benefits of K-12 geographic education (Shelley, 1999). Modern geography is more than just knowing the names of cities and countries. Contemporary geographic education focuses on themes such as understanding the unique characteristics of regions, and how people influence their environments.

British Columbia currently has one course devoted to geography in the curriculum (Geography 12). Students have to wait until grade twelve to take a courses dedicated to geography. Social studies courses tend to focus on History. The *Geography for Life: National Geography Standards* (1994) recommends that students receive appropriate geographic education at all grade levels from kindergarten through to grade twelve. In comparison, the Province of Ontario provides students with geographic education throughout the K-12 curriculum. Starting in grade seven and continuing through grade twelve geography is discussed as its own course in the curriculum. Prior to grade seven the socials studies curriculum provides students with an overview of history and geography. Students in these classes are introduced to the basics of constructing and using traditional forms of geographic information (Province of Ontario, 2003). Ontario also leads the country in incorporating new tools for teaching geographic education (i.e. GIS, web-based atlases,) (Sharpe and Creciollo Best, 2001). The province can offer more advanced geography courses, such as Geomatics (CG04M), at the secondary level because students have been exposed to basic geographical concepts at lower grades. Dale Gregory, chair of the British Columbia/ Yukon chapter of the Canadian Council of Geographic Education (CCGE) suggests:

> *"One of the major failings of the current K-12 curriculum is the lack of Geography spread through out all grade levels".*
> (Dale Gregory Personal Communication. March, 2003)

In addition, students in British Columbia are receiving minimal exposure to new techniques for teaching geography. A teacher from British Columbia expressed the following point in the open portion of the questionnaire:

> *"seems ridiculous though given the state of even the most rudimentary geographic education and constrained technology/teaching budgets. How in the world can we push digital geographic information in the schools if you can't even get regular Geography in the schools?"*

The opinion expressed by this teacher summarizes some of the current sentiment about geography in the Province of British Columbia. There is a sentiment among some educators that using new technologies, such as GIS, to improve K-12 geographic education is a misuse of limited financial resources (Witham-Bednarz and Audet, 1999; Witham-Bednarz and Ludwig, 1997).

The movement to improve geographic education in British Columbia is driven by the BC/ Yukon Division of the Canadian Council of Geographic Education (BCCCGE). The BCCCGE works with teachers in the region to improve the profile of K-12 geographic education. The groups is working to improve the geographic knowledge of teachers, and introduce them to new and existing resources for teaching geography. Improving the profile of geographic education and geographic information literacy requires greater promotion of existing resources which are available to teachers (Fitzpatrick, 1993; Sharpe and Creciollo Best, 2001). Effective change and implementation of new ideas requires consideration of many components, including: policies, instructional resources, professional development, and curriculum materials (Pogrow, 1996).

Environmental Systems Research Institute (ESRI) and Intergraph, two well known GIS software manufactures, both have licensing agreements with British Columbia's Ministry of Education to provide GIS software to schools free of charge. However, few schools are aware of these agreements. ESRI also provides schools with GIS data for all of Canada. Providing teachers with software and quality data is one-way to help teachers overcome barriers, preventing the wide spread adoption of GIS at the K-12 level (Withan-Bednarz and Ludwig, 1997).

Teachers can also access a variety of web-based mapping products at no charge, using hardware available in their classrooms. An advantage of web-based mapping products is they are continuously being updated and expanded. Schools do not have to find additional funds to acquire updated versions of these products, as was the case with their paper equivalents. Also, sites such as the Atlas of Canada provide teachers with a range of learning resources, which can be used in conjunction with the atlas. Included with the atlas is a curriculum guide linking relevant Atlas of Canada maps and other resources to all geography, social studies and history courses in every province and territory for grades seven through twelve (http://atlas.gc.ca/site/english/learning_resources/index.html). The likelihood of teachers using new technologies in the classroom is increased if they are provided with pre-designed course resources that integrate new technology and correspond with their provincial curriculum (Witham-Bednarz and Audet, 1999).

6.3 Improving Geography Education for Teachers

One way to improve the status of geographic education and geographic information literacy at the K-12 level is to improve teacher interest and knowledge in geography. Many teachers have a understanding of geography built around memorizing place names and regional facts. Many teachers also have poor spatial literacy. Spatial literacy is defined as:

> *"the ability to understand and make effective use of spatial information "*
>
> (Commission on Geosciences, Environment and Resources, 1997: 19)

The issue of teacher spatial literacy is overlooked when discussing the use of new technologies to teach geographic education. Instead, discussions of how to improve geographic education have focused on providing teachers with technical competency and an understanding of how to operate new technologies (Palladino, 1996). Their lack of spatial literacy prevents the wide scale diffusion of new techniques for teaching geography (Meyer et al., 1998).

To advance teacher interest and knowledge of geography, geographic education should play a greater role in teacher pre-service education . At the moment, training in geographic education is a small part of a teacher's education program (Trifonoff, 1999). In terms of social studies, teacher education programs are disproportionably weighted towards history (Semple, 2001). Teachers are not required to complete geography courses as part of their undergraduate training programs (Gilsbach, 1997). When teachers do take geography courses, these courses are part of an undergraduate degree and do not educate teachers on how to teach geography at the K-12 level.

In the Faculty of Education at the University of Victoria, pre-service teachers have limited exposure to geography. Table 6.1 illustrates what geography courses are required for pre-service K-12 teachers. Elementary teachers are only required to take canadian studies courses, and the amount of geography discussed in these courses is questionable. Secondary teachers are only required to take geography courses if they intend to peruse social studies or geography as teaching specialties. Otherwise pre-service teachers can take geography courses as electives.

Degree	Geography Courses
Bachelor of Education (Elementary Curriculum)	Approved Canadian Studies course
Bachelor of Education Post-Degree Professional Program (Elementary)	Approved Canadian Studies course
Bachelor of Education Post-Degree Professional Program (Secondary)	Social Studies: Major: Degrees presented for a major must include 3 units of Canadian history, 3 units of introductory geography and one of the following: Geography Emphasis: units of upper-level Geography that include at least 1.5 units dealing with Canadian issues and 7.5 units from human, cultural, economic, regional, Pacific Rim, urban, political and/or geographical technology and methods 3 units upper-level work from History, Anthropology, Pacific and Asian Studies, Classics, Economics, Native Studies, Political Science, Sociology, Urban Studies, Women's Studies or Medieval Studies

Table 6.1: Breakdown of Geography Courses required for Pre-Service Teachers at the University of Victoria (University of Victoria Online Calendar 2003-2004).

Table 6.1 shows the lack of geography in undergraduate teacher education programs. The amount of geographic information discussed in these courses is also not clear. Teachers are familiar with traditional geographic information as they frequently use wall maps as part of the social studies curriculum, but their understanding of it is questionable (Trifonoff, 1999). Their understanding is based on what they learned about geographic information in the course of their teacher education, their own K-12 experiences, and their personal experiences. However, studies have shown the mapping abilities of teachers are often weak. Chido (1993) compared sketch maps drawn by seventh-grade students with those drawn by pre-service elementary teachers. He found no distinguishable difference in the maps of the two groups. The result is disappointing as elementary teachers provide students with their first exposures to geography.

To improve geographic education and a teacher's ability to use geographic information, pre-service teachers should have access to geography as a component of their training. At the pre-service stage, teachers have time to become proficient in geography and geographic information, as they have access to university facilities and instruction by qualified professors (Bednarz and Audet, 1999). Teachers interested in learning about digital geographic information (i.e. GIS, cartography, and remote sensing), would be able to learn about these topics by taking courses from the geography department. In-service teachers interested in geographic information also should have access to these courses. Ryerson University now offers a continuing studies degree for teachers interested in geo-technologies. Courses are designed so teachers can complete courses at their own pace (i.e. summer vacation). The courses in the program are taught by faculty from the geography department, and by local teachers with geo-technology experience.

6.4 Outreach to K-12

Working with local schools and teachers to improve geographic education is one way universities can contribute to their local communities. Science educators at the K-12 level have had success at improving the quality of science education by working with professional scientists. These partnerships provide students with an enhanced science education and the scientists learn how to communicate their ideas to the general public. Scientists have discovered how poor teaching at the university level affects the rest of the education system (Pelaez and Gonzalez, 2002). Similarly, post-secondary geography departments can be supportive resources, which can be used to introduce students to real geography and geographers. Introducing students to geography by demonstrating the subjects applied usage provides students with a positive first exposure to geography (Shelley, 1999). Teachers can build on these experiences when teaching students geographical concepts.

Universities have had limited success working with K-12 teachers to incorporate GIS into geographic education at the K-12 level. Most geography departments have a GIS presence; the presence of GIS can take the form of courses, laboratories and research (Sui, 1995). Universities and colleges in Ontario, for instance, have a strong tradition of working with local schools to implement GIS training programs for teachers (Sharpe and Creciollo Best, 2001).

With the assistance of local geography departments, teachers are better able to overcome the barriers which prevent the wide spread use of GIS in K-12 geographic education. The inclusion of geographical information system within the K-12 classroom has required a “local champion” to take up the cause of GIS. Teachers working on their own initiative to implement GIS in their classrooms, frequently give up on GIS because it requires too much work and interferes with their other teaching responsibilities (Meyer et al., 1998; Bednarz and Audet, 1999). Queens University, Wilfred Laurier University and Sir Sandford Fleming College have programs to provide GIS instruction to teachers. These university projects target in-service teachers.. To facilitate learning, these universities invite local teachers to participate in short-workshop.

6.5 The Role of Workshops

Exposing teachers to technology through workshops and short term educational opportunities are methods commonly used to increase a teacher's technological literacy (Meyer et al., 1998; Palladino, 1993; Rups, 1999; Witham-Bednarz and Audet, 1999). Effective professional development also requires the development of an on going support network within a school and between neighbouring schools (Pogrow, 1996). Workshops targeted at teachers interested in using geographic information, provide teachers with a network of like-minded teachers. The development of these teacher networks help teachers address a variety of issues (Witham-Bednarz and Ludwig, 1997):

- solving technical issues with software or computers;
- sharing of data sources;
- exchanging of ideas on how to incorporate geographic information with the curriculum; and
- exchanging of geographic information curriculum materials.

In Ontario, local support for GIS fostered by teacher workshops resulted in the creation of the grade 12 university preparation course CGO4M: *Geomatics in Action.* The course exposed students to spatial information technologies such as, computer assisted drafting packages and GIS (Sharpe and Creciollo Best, 2001). The following section discusses the outcomes of a geographic information teacher workshop held as part of the 2003 Canadian Association of Geographers (CAG) conference at the Victoria, B.C. May 26-30, 2003.

6.6 Teacher Workshops at the University of Victoria

A teacher workshop was organized as part of the Canadian Association of Geographers Conference 2003 in Victoria, British Columbia. Professional organizations, such as the Canadian Association of Geographers (CAG) have a responsibility to promote geographic education at the K-12 level (Shelley, 1999). Geographers can offer their expertise to help teachers advance the quality of K-12 geographic education. Nine teachers attended the afternoon workshop; seven teachers were from private schools and two were from public schools.

The three-hour workshop, organized by the author, was led by Cheryl Murtland, Kristin Davel, and Becky Davis from Victoria's St. Michaels University School. All three teachers have gone through the process of bringing digital geographic information into their classroom activities. The workshop targeted teachers with no previous experience with digital geographic information. The objective of the workshop was to bring together local teachers from the Greater Victoria area and introduce them to geographic information. The goal was to help local teachers develop a geographic education support network that would help teachers develop new and interesting ways to teach geography. The workshop was separated into two parts. Part one of the workshop introduced teachers to the Canadian Communities Atlas project, while part two introduced teachers to the GIS software package Arc View.

6.6.1 Part One of Workshop

The Canadian Communities Atlas Project (CCAtlas) is a web-based network of local atlases that are accessible to schools in Canada and throughout the world. The Canadian Communities Atlas (CCAtlas) project offers multi-disciplinary activities for accomplishing a number of learning objectives (GeoAccess, 2003). GeoAccess, formerly the National Atlas Information Service of Geomatics Canada, in partnership with a teacher's advisory group from the Canadian Council for Geographic Education, is offering this Internet based project to schools across Canada. Participating school will have their websites included as part of the Atlas of Canada website. Interested teachers are provided with .html templates to build the shell of their atlas, as well as technical support. There are currently 812 community atlases available through the Atlas of Canada website (Canadian Communities Atlas, 2003). Schools are responsible for housing atlas sites on the school's server. Schools select the geographic topics that best reflect their location in Canada. Topics included in a community atlas are divided into three areas: physical, human and economic geography. Schools are encouraged to use: text, audio, and video to communicate ideas about the targeted topics (GeoAccess, 2003).

St. Michaels University School has created a local atlas site (http://www.smus.bc.ca/ccatlas/). Figure 6.2 demonstrates how a community atlas sites is organized. Students download pre-designed icons and buttons from the GeoAccess website to save time and to standardize the appearance of the websites. Students must include background information about where their school is located in Canada. For instance, location information can be included by producing maps or by including a verbal description of their area. The "Where we are in Canada" section in the St. Michaels atlas used a combination of the two methods to communicate their message. The maps for the website were created using the Arc View GIS software and were incorporated around the text (Figure 6.3).

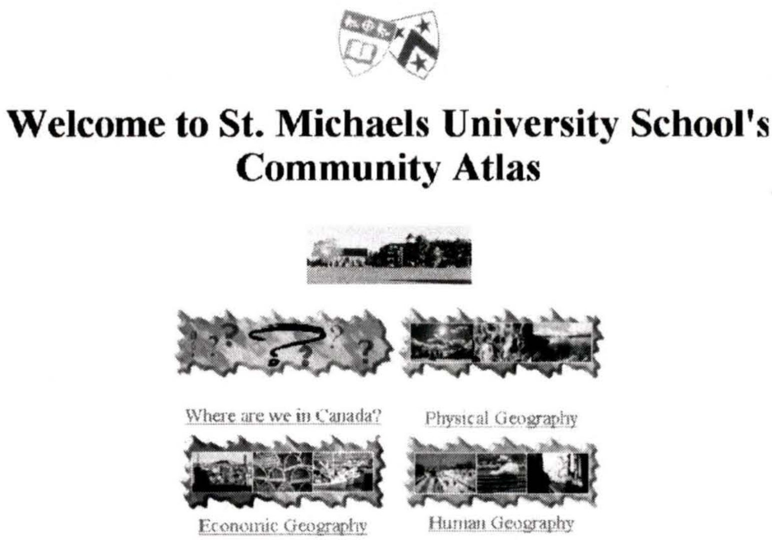


Figure 6.2: Canadian Communities Atlas Created for Victoria by St. Michaels University School (http://www.smus.bc.ca/ccatlas)

6.6.2 Part Two of Workshop

In part two of the workshop teachers were introduced to the GIS software package Arc View 3.2 in a hands on laboratory session. The intent of the workshop was to provide teachers with the skills necessary to use GIS to teach geography. Teachers were introduced to the basic functionality of the Arc View software package. Also, teachers had an opportunity to experiment with the software. The workshop provided teachers with an opportunity to overcome any misconceptions they might have about teaching with GIS. Also it gave teachers an opportunity to ask questions of experienced GIS users.

Teachers worked through the K-12 Quick Start exercises provided by ESRI's school and libraries division (http://k12.esricanada.com/). Through their website, the ESRI schools and library division provides teachers with tutorials which help to increase their familiarity with the Arc View software. Also included on the website are tutorials that focus on basic GIS theory.

Following the workshop, teachers were given an opportunity to critique the workshop; table 6.1 is a summary of the teacher's responses. Four of the nine teachers took the opportunity to critique the workshop. Overall, the teachers found the workshop to be a valuable learning experience. Teachers enjoyed being able to go through the software with the help of knowledgeable classroom teachers. Experienced teachers helped to show less experienced teachers how GIS could be brought into their classrooms. Teachers felt the workshop could have been longer, perhaps filling an entire day.

Question	Responses
What aspects of the workshop did you enjoy?	*"The workshop was valuable- the explanations were clear and concise. I felt the chance to actually go through the software was the best use of time. The moderators came around and answered my questions promptly".* *"Really liked the access to the computers to see the CCAtlas on the Web. Also liked the access to the Arc View to get some hands-on experience using the workbook and the program. Liked having classroom teachers giving the presentation because they understand the delivery systems and the parameters of the program. Also enjoyed the low-key and informal aspects of the presentation. Great to have such a small group and instantaneous feedback on questions and activities"*
What aspects of the workshop could be improved	*"Maybe some more time to browse the Internet on the CCAtlas stuff".* *"Perhaps more computers available and possibly the workshop (could have been longer e.g. a full day). There is a follow up teacher workshop at SMUS in the summer, but not all teachers are able to attend".*

Table 6.2: Summary of Teacher Critiques for the CAG teacher workshop

Where in Canada is St. Michaels University School?

Canada is a northern country stretching from "Sea to Sea to Sea". It is bounded on the west by the Pacific Oce
north by the Arctic Ocean and the east by the Atlantic Ocean. We share our southern border with the United S
America.

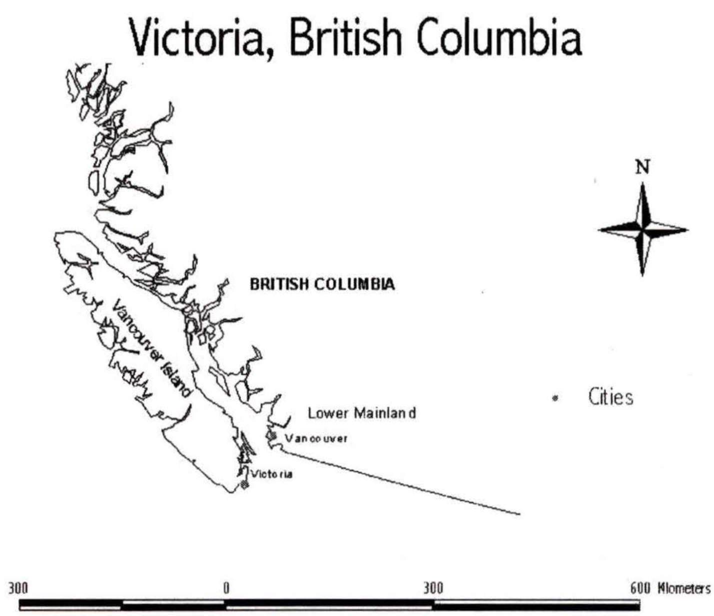


Figure 6.3: Sample of How Geographic Information is used within Communities Atlas (http://www.smus.bc.ca/ccatlas/mappage/mappage.htm.)

6.7 Summary

The results of the content analysis in Chapter Five indicated that digital geographic information is not well represented in British Columbia's current K-12 curriculum. Digital geographic information is becoming the favoured medium for accessing geographic information and K-12 curricula will have to adjust to the new reality. However, before topics such as K-12 geographic information literacy can be addressed, the larger issue of improving K-12 geographic education needs to be addressed.

Improving geographic education will require improvements in pre-service teachers' education about geography. Pre-service teachers should receive greater exposure to geography and geographic information in the course of their education. In service teachers should also have access to this education. Both university and college departments of geography need to reach out to local school and promote the benefits of geographic education. As an example, geography departments in Ontario have worked with local schools to introduce GIS into K-12 geography courses. Workshops with teachers were used to introduce and build teachers knowledge of GIS.

As part of the 2003 Canadian Association of Geographers conference a workshop was held with local teachers to introduce digital geographic information and its application to K-12 geographic education. The workshop discussed the Canadian Communities Atlases project and GIS as tools to improve geographic education. Overall teachers enjoyed the workshop. Workshop participants enjoyed and benefited learning from teachers who have experience teaching geography with digital geographic information. To increase the usage of digital geographic information, teachers need follow up support at the school and classroom level.

7. CONCLUSION

7.1 Introduction

As civilization has evolved, so has the use of geographic information. Traditionally, society has utilized geographic information in an analog, paper format. However, improvements in digital technology have challenged the paradigm of the paper map. The move towards an information-based economy has made digital information a presence in everyday activities. In order to adjust to this new presence, the public needs to build its information literacy. Geographic information is a specialized type of information literacy, and as a result users need geographic information literacy (GIL). GIL is a unique form of information literacy that includes an understanding of concepts and abilities that allow users to properly understand geographic information. Introducing GIL at the K-12 level offers interdisciplinary opportunities that bring together material from information technology, science and mathematics curricula to compliment the social studies curriculum. This approach provides students with the range of knowledge necessary to function effectively in an information-based economy.

7.2 Chapter Summaries

The objective of this thesis is to examine how geographic information literacy is represented in the current British Columbia K-12 curriculum. An online questionnaire was distributed to geographic information users via online mailing lists. Geographic information users were asked to rate a list of eighty-one concepts and abilities related to the usage of geographic information. Concepts and abilities were rated from "essential" to "not appropriate". The list drew on material related to traditional and digital geographic information and also information literacy. Respondents could also include concepts and abilities not mentioned on this list through an open-ended questionnaire.

The results of the questionnaire provided a list of essential and important concepts and abilities for K-12 geographic information literacy, as defined by geographic information users. The questionnaire results formed the basis for a content analysis of selected sections of the British Columbia K-12 curriculum. The content analysis used the content analysis software NUD*IST 5® to locate geographic information literacy content within selected curriculum documents. The content analysis targeted traditional subject areas associated with the use of geographic information such as social studies and geography. Subject areas not immediately associated with geographic information such as science and mathematics were also included in the analysis.

Chapter Four presented the results of the online questionnaire. Overall geographic information users felt the traditional geographic information concepts and abilities were more important than digital geographic information concepts and abilities for students at the K-12 level. Questionnaire respondents had a stronger opinion as to which essential traditional geographic information concepts and abilities are appropriate for the K-12 level. This was not the case with digital geographic information, as only one digital geographic information concept was rated as essential. Greater exposure to digital geographic information will allow geographic information users to develop similar confidence about digital geographic information concepts and abilities at the K-12 level.

In Chapter Five the results of the online questionnaire from Chapter Four were developed into a coding frame for geographic information literacy. Overall, traditional geographic information and information literacy concepts and abilities were reasonably represented within the selected portions of the curriculum. Yet, digital geographic information was not well represented in British Columbia's curriculum. As a comparison, the curriculum for the Geomatics 12 course (CGO4M) in Ontario was analyzed for geographic information literacy content. Ontario is leading the country in providing students with both traditional and digital geographic information knowledge. Ontario's geomatics course does a better job representing all three aspects of geographic information literacy.

Chapter Six outlines recommendations for improving geographic information literacy in the K-12 curriculum. Part of raising the profile of GIL at the K-12 level involves raising the overall profile of geography at the K-12 level. This also means changing how teachers are taught to teach geography. Improving K-12 geographic education necessitates greater collaboration between post secondary departments of geography and their local schools. These departments possess expertise and resources that can be used to improve geographic education. An example of K-12-University collaboration is the workshops held by universities to introduce GIS into the K-12 geography curriculum. A digital geographic information workshop was held at the University of Victoria. The workshop focused on the Canadian Communities Atlas project and Arc View GIS to teach geography.

7.3 Future Research

The results of this research showed that traditional geographic information and information literacy concepts and abilities are reasonably represented in the current K-12 curriculum. The next step in this research is to examine how the presence of these topics in the curriculum translates into classroom instruction. The results of the content analysis showed a lack of digital geographic information within the current K-12 curriculum. The next progression in this research agenda is to analyze the essential and important digital geographic information concepts and abilities to determine which concepts and abilities are appropriate for the K-12 curriculum. Also, it will be necessary to examine if online questionnaires are an appropriate means of gathering the opinions of teachers or whether their opinions are better expressed through traditional (paper based) questionnaire techniques. Currently research is underway to investigate the validity of online surveys as research tools for the social sciences (Coomber, 1997; Gaddis, 1998). When dealing with groups possessing technical expertise, such as digital geographic information users, an online questionnaire was an appropriate method to gather their ideas. However, when dealing with groups such as teachers, their levels of technical expertise and familiarity cannot be assumed. In these situation a mixed approach of paper based and online questionnaire might be more appropriate.

Future research will also have to examine the issue of whether there is an explicit division between traditional and digital GIL. For the purposes of the research undertaken in this thesis it was deemed necessary to work from a simple division of concepts and abilities into either digital or traditional geographic information. In retrospect the research has shown that a GIL continuum might exist. Some GIL concepts and abilities are applicable only to traditional geographic information, others apply only to digital GIL, and a bulk of concepts and abilities are seemingly applicable to both. Future research involving K-12 GIL would help to clarify the nature of this continuum.

Teachers and curriculum designers need to be consulted about finding meaningful ways to bring digital geographic information into the classroom. For instance, will the focus be on teaching students about concepts and abilities related to geographic information literacy or will it be on using these concepts and abilities to demonstrate the application of geographic information? A similar debate has occurred amongst GIS educators about whether to teach about GIS or to teach with GIS (Kieper, 1999; Sui, 1995). At the K-12 level a compromise of the two arguments would be appropriate. Training should focus on teaching teachers how to teach about GIL, as well as teaching them how to teach with GIL.

Part of improving the usage of digital geographic information at the K-12 level will involve providing teachers with training in the subject. Training can be in the form of workshops, but it can also include web-based tutorials targeted at K-12 teachers. Further examination of the issue is necessary to develop professional development initiatives that focus on geographic information. Research should concentrate on what background materials teachers need to teach with digital geographic information. For instance, the Geography Department at the University of Victoria should develop a geography course, which teachers could take as part of their training. The course would introduce teachers to basic geographic concepts and abilities. Part of the course would focus on teaching teachers about concepts and abilities relating to digital and traditional geographic information. Other parts would offer teachers curriculum materials and demonstrate how to teach with GIL, at the different grades from K to12.

Research conducted as part of this thesis indicates a firm base for geographic information literacy in the current K-12 curriculum. However, further research as discussed in Chapter Seven is needed to bring digital geographic information into the curriculum, thus allowing all components of geographic information literacy to be represented in British Columbia's K-12 curriculum

REFERENCES

Alexa, Melina, and Cornelia Zuell. "Text Analysis Software: Commonalities, Differences and Limitations: The Results of a Review." Quality & Quantity 34.3 (2000): 299-321.

Alvermann, Donna. "Effective Literacy Instruction for Adolescents." Journal of Literacy Research 34.2 (2002): 189-208.

American Association for the Advancement of Science. A.A.A.S. Project 2061/ Benchmark for Science Literacy. 2003. Available: www.project2061.org/tools/bsl/default.htm. Oct 18 2003.

Anderson, Kathleen, and Gaea Leinhardt. "Maps as Representations: Experts Novice Comparisons of Map Projection Understanding." Cognition and Instruction 20.3 (2002): 283-321.

Anderson, Ronald, and Jennifer Helms. "The Ideal of Standards and Reality of Schools: Needed Research." Journal of Research in Science Teaching 38.1 (2001): 3-16.

Asche, Hartmut. "Mapping and Map Use in the Age of the of Information Technology." LIBER Quarterly 8.2 (1998): 150-57.

Associated Press. Despite War, Commercial Photos of Iraq Still for Sale. March 24 2003. USA Today. Available: http://www.usatoday.com/tech/world/iraq/2003-03-24-war-images_x.htm. June 16 2003.

Association of College and Research Libraries. "Information Literacy Competency Standards for Higher Education." Chicago, Illinois: Association of College and Research Libraries, 2000.

Audet, Roger, and Joseph Paris. "G.I.S. Implementation Model for Schools: Assessing the Critical Concerns." Journal of Geography 96.6 (1997): 293-300.

Babbie, Earl. The Basics of Social Research. Vol. 2. Belmont, Calif.: Wadworth, 2000.

Baker, Thomas. "Success with G.P.S.: A Look at Hand Held Technology in the Science Classroom." Science Teacher 68.9 (2001): 38-41.

Bauer, Martin. "Qualitative Approaches for Texts, Image and Sound: A Practical Approach." Qualitative and Quantitative Methods. Eds. M. Bauer and G. Gaskell, 2000.

Bianchini, J, and G Kelly. "Challenges of Standards-Based Forms: The Example of the California Science Content Standards and Text Book Adoption Process." Science Education 87.3 (2003): 378-89.

British Columbia Social Studies Task Force. Teaching for the Understanding in Social Studies. Victoria, British Columbia: Ministry of Education, 1999.

Broda, Herbet, and Ryan Baxter. "Using G.I.S. And G.P.S. Technology as an Instructional Tool." Clearing House 76.1 (2002): 49-52.

Buckingham, David, Margaret Scanlon, and Julian Sefton-Green. "Selling the Digital Dream." I.C.T Pedagogy and the Curriculum. Eds. Avril Loveless and Viv Ellis. London, England: Routledge Farmer, 2001. 20-40.

Burniske, R.W. "Composing Ourselves Online: Broadening the Definition of Computer Literacy." Ubiquity, 1.12 (2000). Available Online: http://www.acm.org/ubiquity/book/r_burniske_2.html Dec 9, 2003

Burroughs, Peter, and Rachael McDonnell. Principles of Geographical Information Systems. New York: Oxford, 1998.

Bybee, Rodger. Achieving Scientific Literacy: From Purposes to Practices. Portsmouth NH: Heinemann, 1997.

Canadian Communities Atlas. Canadian Communities Atlas - Project Gallery Search. March 3, 2003. GeoAccess. Available: http://atlas.gc.ca/ccatlas/map.php. June 18 2003.

Canadian Council for Geographic Education. Canadian National Standards for Geography: A Standards Based Guide to K-12 Geography. Royal Canadian Geographical Society, 2001.

Carter Peoples, Deborah, and John Krygier. "Geographic Information Literacy." North American Cartographic Information Society. Columbus Ohio, 2002.

Catholic District School Board Writing Partnership. Course Profile: Geomatics: Geo-Technologies in Action Grade 12 University/College Preparation (Cgo4m). 2002. Ontario Ministry of Education. Available: http://www.curriculum.org/occ/profiles/12/pdf/CGO4MC.pdf. June 27 2003.

Chapin, June, and Rosemary Messick. Elementary Social Studies. fifth ed. Boston: Allyn and Bacon, 2002.

Chido, John. "Mental Maps: Pre-Service Teachers' Awareness of the World." Journal of Geography 92.3 (1993): 110-17.

Chrisman, Nicholas. "What Does 'G.I.S.' Mean?" Transactions in GIS 3.2 (1999): 175-86.

Clarke, Keith. "Maps and Mapping Technologies of the Persian Gulf War." Cartography and Geographic Information Systems 19.2 (1992): 80-87.

Clay, John. "Science Literacy: Whose Science? Whose Literacy?" Challenging Ways of Knowing in Math, Science and English. Eds. Dave Barker, John Clay and Carol Fox. London: Falmer, Press, 1996. 194-93.

Commission on Geosciences, Environment and Resources. The Future of Spatial Data and Society: Summary of a Workshop. Washington DC, 1997.

Coomber, R. "Using the Internet for Survey Research." Sociological Research Online 2.2 (1997).

Couper, Mick, Michael Traugott, and Mark Lamias. "Web Survey Design and Administration." Public Opinion Quarterly 65 (2000): 230-53.

Couture, Jean Claude. "Teachers' Work: Living in the Culture of Insufficiency." Tech High: Globalization and the Future of Canadian Education. Ed. Martha Moll. Halifax, Nova Scotia: Fernwood Press, 1997. 139-67.

Crampton, Jeremy. "The Convergence of Spatial Technologies." Cartographic Perspectives 30.2 (1998): 3-5.

Crawford, Scott, Mick Couper, and Mark Lamias. "Web Surveys." Social Science Computer Review 19.2 (2001): 146-60.

Cuban, Larry. Teachers and Machines. New York: Teachers College Press, 1986.

December, John. Intro to Internet - W.W.W. Net Use. 2003. December Communications. Available: http://www.december.com/web/text/tutor/netuse.html. June 15 2003.

Demers, Michael. Fundamentals of Geographic Information Systems. New York: John Wiley and Sons, 1997.

Dent, Borden. Cartography: Thematic Map Design. Boston: McGraw Hill, 1999.

DiBiase, David. "Rethinking Laboratory Education for an Introductory Course on Geographic Education." Cartographica 33.4 (1996): 61-71.

Didsbury, Howard. "Literacy in the Future." Literacy: A Redefinition. Eds. Nancy Ellsworth, Carolyn Hedley and Anthony Baratta. Hillsdale, New Jersey: Erlbaum Associates, 1994. 281-84.

Dillman, Don. Mail and Telephone Surveys : The Total Design Method. 1st ed. New York: Wiley, 1978.

Dohan, Daniel, and Martin Sanchez-Jankowski. "Using Computers to Analyze Ethnographic Data." Annual Reviews Sociology 24 (1998): 477-98.

Donaldson, Daniel. "With a Little Help from Our Friends: Implementing Geographic Information Systems (G.I.S.) in K-12 Schools." Social Education 65.3 (2001): 147-50.

Dunn, Kathleen. "Assessing Information Literacy Skills in the California: A Progress Report." The Journal of Academic Librarianship 28.1 (2002): 26-35.

Dye, Beth. Ccge Newsletter May 2003: British Columbia and Yukon Report. 2003. Canadian Council for Geographic Education. Available: www.ccge.org/ccge/english/whoWeAre/may03_newsletter/may03_BCYukon.htm. July 31 2003.

Ercegovac, Zorna. "Bridging the Knowledge Gap between Secondary and Higher Education." College and Research Libraries 64.1 (2003): 75-81.

ESRI. "B.C. Ministry of Education Selects Arc View." ArcNorth News 2001: 9.

Evans, Donald L. A Nation Online: How Americans Are Expanding Their Use of the Internet. 2002. National Telecommunications and Information Administration. Available: http://www.ntia.doc.gov/ntiahome/dn/html/toc.htm. June 15 2003.

Fitzpatrick, Charlie. "Teaching Geography with Computers." Journal of Geography 92.4 (1993): 156-59.

Flournoy, Brenda, Janice Cook-Bax, and Lillian Harris. "The Science-Mathematics Connection: Using Technology in an Interdisciplinary Module." Science Teacher 68.6 (2001): 63-66.

Ford, Carole, Larry Yore, and Robert Anthony. "Reforms, Visions, and Standards: A Cross-Curricular View from an Elementary School Perspective." National Association for Research in Science Teaching. Oakbrook, Illinois, 1997. 2-40.

Froese-Germain, Bernie. "All Aboard." The Bulletin: Newfoundland and Labrador Teacher's Association 41.4 (1998).

Gaddis, S. "How to Design Online Surveys." Training and Development 52.6 (1998): 67-71.

Gartner, Group. Average Us Internet User over 40. 2002. website. NUA Internet Surveys. Available: http://www.nua.ie/surveys/?f=VS&art_id=905356144&rel=true. June 12 2003.

GeoAccess. Canadian Communities Atlas- Introduction. July 11, 2002. website. Natural Resources Canada. Available: http://atlas.gc.ca/site/english/learning_resources/ccatlas/participate/guides/c11.htm. June 18 2003.

Geography Education Standards, Project. Geography for Life, National Geography Standards. Washington DC: National Geographic Research & Exploration, 1994.

Gibbins, Roger. "Navigating the Information Rich Society." Navigating the Information Rich Society. Eds. Jane Kelly and George Stacey. Calgary, Alberta: Calgary Institute of the Humanities, 1998. 1-7.

Gilsbach, Michael T. "Improvement Needed: Pre-Service Geography Teacher Education." Social Studies 88.1 (1997): 35-39.

Goodchild, Michael. "Communicating Geographic Education in a Digital Age." Annals of the Association of American Geographers 90.2 (2000): 344-55.

Goodchild, Michael, and James Proctor. "Scale in a Digital Geographic World." Geographical and Environmental Modelling 1.1 (1997): 5-23.

Government of Canada. Preparing Canada for a Digital World. Ottawa, Canada: Information Highway Advisory Council, 1997.

Gower, J. "Measures of Similarity, Dissimilarity and Distance." Encyclopedia of Statistical Sciences. Eds. S. Kotz, N.L. Johnson and Read C.B. Vol. 5. New York: John Wiley and Sons, 1985. 397-405.

Gregg, Madeline, and Gaea Leinhardt. "Mapping out Geography: An Example of Epistemology and Education." Review of Educational Research 64.2 (1994): 311-61.

Gregory, Dale. "G.I.S. And K-12." GeoTec 2003, Vancouver B.C. March 18, 2003.

Grime, Alexander R. "Teachers as Map Users." Symposium on the Influence of the Map User on Map Design. Eds. Henry W. Castner and Gerald McGrath. Queen's University, Kingston Ont., 1970. 1-6. Vol. 2 of Cartographica; monograph.

Harris, Theodore, and Richard Hodges. The Literacy Dictionary. Newark, Delware: International Reading Association, 1995.

Hefzallah, Michail Ibrahim. The New Educational Technologies and Learning. Springfield, ill: Thomas, 1999.

Heywood, Ian, Sarah Cornelius, and Steve Karver. An Introduction to Geographical Information Systems. London, England: Longman, 1998.

Hocking, Diana, and C. Peter Keller. "Analysis of State and Provincial Atlas Reviews." Professional Geographer 45.1 (1993): 73-83.

Hodson, Derek. "Time for Action: Science Education for an Alternative Future." International Journal of Science Education 25.6 (2003): 645-70.

Holland, Peter. "A Revolutionary Syllabus?" New Zealand Journal of Geography 106.3 (1998): 1-6.

Jarolimek, John, Clifford Foster, and Richard Kellough. Teaching and Learning in the Elementary School. Upper Saddle River, New Jersey: Merrill-Prentice Hall, 2001.

Johnson, R.A., and D.W. Wichern. Applied Multi-Variate Statistical Analysis. 3rd ed. Edgewood Cliffs, New Jersey: Prentice Hall, 1992.

Jones, Lynn, and Rosemarie Falanga. Rewarding Students' Skepticism: Promoting Information Literacy in the Classroom. Aug. 17, 2001. K-12 Digital Fellows Project. Available: http://sunsite.berkeley.edu/calheritage/k12project/infoliteracy.html. May 20 2003.

Kadmon, Naftali. "Educating the Educatee and the Educator." International Yearbook of Cartography 28.1 (1988): 221-28.

Kahneman, Daniel, Paul Slovic, and Amos Tversky, eds. Judgment under Uncertainty: Heuristics and Biases. Cambridge, New York: Cambridge University Press, 1982.

Karver, Steve, et al. "Accessing Geographical Information Systems over the World Wide Web: Improving Public Participation in Decision Making." Information Infrastructure and Policy 6.3 (2000): 157-71.

Keiper, Timothy. "G.I.S. For Elementary Students: An Inquiry into a New Approach to Learning Geography." Journal of Geography 98.3 (1999): 47-59.

Kelle, Udo. Computer-Aided Qualitative Data Analysis: Theory, Methods and Practice. Eds. Udo Kelle, Gerald Prein and Katherine Bird. London: Sage Publications, 1995. 1-30.

Keller, C. Peter. "The Map Library's Future." Cartographic Perspectives 38.3 (2001): 73-77.

Keller, C. Peter, Diana Hocking, and Colin Wood. "Planning the Next Generation of Regional Atlases: Input from Educators." Journal of Geography 94.3 (1995): 412-18.

Kemp, Karen. Summary of Survey Conclusions. February 7 1999. Available: http://www.institute.redlands.edu/users/kemp/survey_summary.html. June 15 2003.

Kemp, Karen, and Michael Goodchild. "Developing a Curriculum in Geographic Information Systems: The National Center for Geographic Information and Analysis Core Curriculum Project." Journal of Geography in Higher Education 15.2 (1991): 121-32.

Kerski, Joseph. "The Implementation and Effectiveness of Geographic Information Systems Technology and Methods in Secondary Education." PhD. Dissertation. University of Colorado at Boulder, 2000.

Kirman, Joseph. "Elementary Education: What Is Project Omega." Aviation/Space 7.2 (1980): 18.

---. Elementary School Studies. Toronto: Allyn and Bacon, 1996.

---. "A Teacher's Introduction to Remote Sensing." Journal of Geography 96.3 (1997): 171-76.

Kirman, Joseph, and Stephanie Busby. "The Ability of Grade 5 Students to Use Radarsat Satellite Images." Alberta Journal of Educational Research 46.2 (2000): 138-48.

Kirman, Joseph, and Chris Jackson. "Grade 6 Children's Abilities to Use a Landsat Digital Data Computer Program." Journal of Geography 92.6 (1993): 254-62.

Kirman, Joseph, and Lorna Nyitrai. "The Ability of Sixth Grade Children to Use Radarsat Satellite Images." Journal of Geography 97.2 (1998): 56-62.

Kirman, Joseph, and Marie Unsworth. "Digital Data in the Grade 6 Classroom." Journal of Geography 91.6 (1992): 241-46.

Kitchin, Robert, et al. "Belfast without Sight: Exploring Geographies of Blindness." Irish Geography 31.1 (1998): 34-46.

Kleiman, Glenn. Myths and Realities About Technology in K-12 Schools. April 2000. Available: http://www.edc.org/LNT/news/Issue14/feature1.htm14. June15, 2003

Lankshear, Colin, Llana Snyder, and Bill Green. Teachers and Techno-Literacy. Sydney, Australia: Allen and Unwin, 2000.

Lawson, Michael, et al. Embedding Information Technology in the Curriculum. Adelaide, Australia: Flinders Institute for the Study of Teaching, 1999.

LeCourt, Donna. "Technology as Material Culture." I.C.T Pedagogy and the Curriculum. Eds. Avril Loveless and Viv Ellis. London, England: Routeledge Farmer, 2001. 84-103.

Liben, Lynn, Kim Kastens, and Lisa Stevenson. "Real-World Knowledge through Real-World Maps: A Developmental Guide for Navigating the Educational Terrain." Developmental Review 22 (2002): 267-322.

Liberman, Ann, and Lynne Miller. "Teaching and Teacher Development: A New Synthesis for a New Century." Education in a New Era. Ed. Ronald S. Brandt. Alexandria Virginia: ASCD, 2000.

Linn, S.E. "The Effectiveness of Interactive Maps in the Classroom: A Selected Example in Studying Africa." Journal of Geography 96.3 (1997): 164-70.

Mackenzie, Jim. "The Idea of Literacy." Journal of Philosophy of Education 34.2 (2000): 209-28.

Madge, Clare, and Henrietta O'Connor. "Online with E-Mums: Exploring the Internet as a Medium for Research." Area 34.1 (2002): 92-102.

Maguire, David J., Michael Goodchild, and David W. Rhind, eds. Geographical Information Systems: Principles and Applications. Vol. 1. 2 vols. Essex, England: Wiley, 1991.

Mathews, Hugh. "Children as Map Makers." Geographical Magazine March (1986): 124-29.

Mayhew, Susan. A Dictionary of Geography. 2nd ed.: Oxford University Press, 1997.

McWilliams, Harold, and Paul Rooney. "Mapping Our City: Learning to Use Spatial Data in the Middle School Classroom." Tools for Learning: How Technology Masks and Illuminates Cognitive Dilemmas. Chicago Illinois, 1997. 1-6.

Merry, Carolyn, and Stephanie Stockman. "Educational Outreach Activities for Landsat-7." Remote Sensing of Environment 78 (2001): 217-20.

Meyer, Judith, et al. "G.I.S. In the K-12 Curriculum: A Cautionary Note." The Professional Geographer 51.4 (1998): 571-78.

Ministry of Education. Information Technology Curriculum Rationale. 1999. Government of British Columbia. Available: http://www.bced.gov.bc.ca/irp/it810/itration.htm. June 27 2003.

---. K-12 Curriculum and Learning Resources (Integrated Resource Packages). 2003. Government of British Columbia. Available: http://www.bced.gov.bc.ca/irp/. June 27 2003.

---. Networks for Teacher Development in Social Studies. 2001. Government of British Columbia. Available: www.bced.gov.bc.ca/taskforce/social_studies/ssnetworks1.htm. July 31 2003.

---. The Primary Program : A Framework for Teaching. 2000. Government of British Columbia. Available: http://www.bced.gov.bc.ca/primary_program/toc.htm. June 20 2003.

---. Social Studies 11: Skills and Processes Ii, Prescribed Learning Outcomes. 1998. Government of British Columbia. Available: http://www.bced.gov.bc.ca/irp/ss11/ss11sp2.htm. June 27 2003.

---. Social Studies Networks Progress Report. 2001. Government of British Columbia,. July 31 2003.

Moll, Martha. "Canadian Classrooms on the Information Superhighway: Making the Connection." Tech High: Globalization and the Future of Canadian Education. Ed. Martha Moll. Halifax: Fernwood Publishing, 1997. 33-64.

Morris, Shamos. "The Myth of Scientific Literacy." Liberal Education 82.3 (1996): 44-50.

Moseley, William G. "Computer Assisted Comprehension of Distant Worlds: Understanding Hunger Dynamics in Africa." Journal of Geography 100.1 (2001): 32-45.

Muehrcke, Philip. "The Logic of Map Design." Cartographic Design: Theoretical and Practical Perspectives. Eds. C. Peter Keller and Cliff Wood: John Wiley and Sons, 1996. 271-85.

National Council of Geographic Education. National Council of Geographic Education: Remote Sensing Task Force. 2003. National Council of Geographic Education. Available: http://www2.oneonta.edu/~baumanpr/ncge/rstf.htm. June 20 2003.

Norris, Stephen, and Linda Phillips. "How Is Literacy in Its Fundamental Sense Central to Scientific Literacy." Science Education 87.2 (2003): 224-40.

Obenhaus, Ben. "Maps: Knowing Enough to Help Users Help Themselves." Research Strategies 8.3 (1990): 144-49.

O'Connell, I.J., and C. Peter Keller. "Design of Decision Support for Stakeholder-Driven Collaborative Land Valuation." Environment and Planning B-Planning and Design 29.4 (2002): 607-28.

O'English, Lorna. "Book Review: Information Literacy: Theory and Practice." Journal of Academic Librarianship 28.1 (2002): 78-79.

Oldakowski, Raymond. "Activities to Develop a Spatial Perspective among Students in Introductory Geography Courses." Journal of Geography 100.3 (2001): 243-50.

Oxford University Press. Oxford English Dictionary. 3rd Edition. 2003. Oxford University Press. Available: http://www.oed.com/. June 30 2003.

Pachler, Norman. "Connecting Schools and Pupils." Issues in Teaching Using I.C.T. Ed. Marilyn Leask. London, England: Routledge Farmer, 2001. 15-30.

Palladino, Stephen. "G.I.S. And Secondary Education in the United States." Yearbook of the AGI (1993): 304-09.

Palys, Ted. Research Decisions: Quantitative and Qualitative Perspectives. Toronto: Harcourt Brace Jovanovich 1992.

---. Research Decisions: Quantitative and Qualitative Perspectives. Second Ed Toronto: Harcourt Brace Jovanovich, 1998.

Pelaez, Nancy J., and Barbara L. Gonzalez. "Sharing Science: Characteristics of Effective Scientist-Teacher Interactions." Advances of Physiological Education 26.3 (2002): 158-67.

Peterson, Michael P. "Cartography and the Internet: Implications for Modern Cartography." 16th North American Cartographic Information Society Conference. San Antonio, TX, 1996.

---. "Cartography and the Internet: Introduction and Research Agenda." Cartographic Perspectives 26.3 (1997): 3-12.

Pickles, John. "Representation of Geographic Information in an Electronic Age." Ground Truth: The Social Implications of Geographic Information Systems. Ed. John Pickles. New York: Guilford Press, 1995. 1-27.

Plotnick, Eric. "Information Literacy: Definitions and Perspectives." Teacher Librarian 28.1 (2000): 27-29.

Pogrow, Stanley. "Reforming the Wannabe Reformers." Phi Delta Kappan 77.10 (1997): 656-63.

Postman, Neil. The End of Education. New York: Alfred A. Knopf, 1995.

Pride, Peggy. "Using Technology to Enhance Geography Education." Media and Methods 33.5 (1997): 8.

Province of Ontario Ministry of Education. Social Studies Grades 1 to 6 History and Geography. 1998. Province of Ontario Ministry of Education. Available: http://www.edu.gov.on.ca/eng/document/curricul/social/social.html. Dec 7 2003.

Pullin, D.C. "Learning to Work - the Impact of Curriculum and Assessment Standards on Education Opportunity." Harvard Education Review 64.1 (1994): 31-54.

Reichard, James. "A Computer Program for Use with Pace and Compass Exercises." Journal of Geo-Science Education 50.5 (2002): 544-48.

Rups, Pamela. "Training Instructors in New Technologies." The Journal 26.6 (1999): 66-70.

Sandford, Herbert. "The Future of the School Pupils Desk Atlas." The Cartographic Journal 22.2 (1985): 3-10.

Semple, Stuart. "The Non-Geographer: Overlooked But Not Forgotten." Journal of Geography in Higher Education 25.2 (2001): 261-67.

Sharpe, Bob, and Angela Creciollo Best. "Teaching G.I.S. In Ontario's Secondary Schools." G.I.S.: A Sourcebook for Schools. Ed. David R. Green, 2001. 73-85.

Sheatsley, Paul. "Questionnaire Construction and Item Writing." Handbook of Survey Research. Ed. James Wright Peter Rossi, Andy Anderson: New York: Academic Press, 1983: 195-230.

Shelley, Fred. "Geographic Education Research and the Changing Institutional Structure of America Education." Professional Geographer 51.4 (1999): 592-597.

Shenk, David. Data Smog: Surviving the Information Glut. San Francisco: HarperCollins, 1997.

Singer, A.J. Social Studies for Secondary Schools: Teaching to Learn, Learning to Teach. Mahwah, New Jersey: Erlbaum Associates, 1997.

Stiendorf, Sara. They're All over the Map. 2002. Internet. Christian Science Monitor. Available: www.csmonitor.com/2002/0409/p11s01-legn.htm2002. June 5, 2003.

Stoll, Clifford. Silicon Snake Oil. New York: DoubleDay, 1996.

Stoltman, Joseph, C. Sonya Wardley, and Pavan Kandi. "Launching Geographic Education into the 21st Century: The View from the United States." Cahiers de Geographie du Quebec 43.120 (1999): 413-35.

Suchan, Trudy, and Cynthia Brewer. "Qualitative Methods for Research on Mapmaking and Map Use." Professional Geographer 52.1 (2000): 145-54.

Sui, Daniel, and Michael Goodchild. "G.I.S. As Media?" International Journal of Geographic Information Science 15.5 (2001): 387-90.

Trifonoff, Karen. "Creativity, Art and Cartography in Geographic Education." Cartographic Perspectives 33.2 (1999): 48-58.

---. "Going Beyond Location: Thematic Maps in Early Elementary Grades." Journal of Geography 94.4 (1995) 368-374.

University of Victoria. University of Victoria Calendar 2003-2004. May 19, 2003. University of Victoria. Available: http://web.uvic.ca/calender2003/. Dec 7 2003.

van Elzakker, C. "Use of Maps on the Web." Web Cartography. Eds. Menno-Jan Kraak and Corne P.J.M. van Elzakker. New York: Taylor and Francis, 2001. 61-82.

---. "The Users of Geographic Information." Web Cartography. Eds. Menno-Jan Kraak and Corne P.J.M. van Elzakker. New York: Taylor Francis, 2001. 21-44.

Webster, Frank. Theories of the Information Society. London, England: Routledge, 1995.

Welborn, Victoria, and Bryn Kanar. Building Web Sites for Science Literacy. Winter. 2000. Science and Technology Section, Association of College and Research Libraries, Available: www.library.ucsb.edu/istl/00-winter/article2.html. June 30 2003.

Wiegand, Patrick. "Atlases as a Teaching Resource: Findings from a National Survey." Geography 83.4 (1998): 358-66.

Wikle, Thomas. "Survey Defines Background Coursework for G.I.S Education." GIS World 7.6 (1994): 53-55.

Wilke, Thomas, and Dean Lambert. "The Global Positioning System and Its Integration into College Geography Curricula." Journal of Geography 95.5 (1996): 186-93.

Witham Bednarz, Sarah, and Gail Ludwig. "Ten Things Higher Education Needs to Know About G.I.S. In Primary and Secondary Education." Transactions in GIS 2.2 (1997): 123-33.

Witham-Bednarz, Sarah, and Roger Audet. "The Status of G.I.S. Technology in Teacher Preparation Programs." Journal of Geography 98.2 (1999): 60-67.

Yore, Larry, Gay Bisanz, and Brian Hand. "Examining the Literacy Component of Science Literacy: 25 Years of Language Arts and Science Research." International Journal of Science Education 25.6 (2003): 689-725.

Yore, Larry, Brian Hand, and Vaughan Prain. "Scientists as Writers." Science Education 86.5 (2002): 672-92.

Zhao, Y., et al. "Conditions for Classroom Technology Innovations: Executive Summary." Teachers College Record 104.3 (2002): 482-515.

APPENDIX ONE – QUESTIONNAIRE REFERENCE

The following are the references used to build the initial list.

Allan, A. (1997). Maths For Mapmakers. Caithness, Scotland, Whittles Publishing Services, (1997).

Bawde, D. "Information and Digital Literacies: A Review of the concepts." Journal of Documentation. 57(2): 218-259, (2001).

Brannon, Gary. Practical Cartography: A review of current techniques. Waterloo Ontario, Escart Press, (1992).

Burroughs, Peter, and Rachael McDonnell. Principles of Geographical Information Systems. New York, Oxford, (1998).

Chrisman, Nicholas Exploring Geographic Information Systems, Wiley and Sons, (1996).

Dent, Borden. Cartography: Thematic Map Design. Boston, McGraw Hill, (1999).

Dunn, K. "Assessing Information Literacy Skills in the California: A Progress Report." The Journal of Academic Librarianship 28(1): 26-35, (2002).

Heywood, Ian, et al., An Introduction to Geographical Information Systems. England, Longman, (1998).

Information Literacy, Competency Standards for Higher Education. May 10,2002 American Library Association, Association of College and Research Libraries. August 8, 2002 <http://www.ala.org/acrl/ilcomstan.html>.

International Cartographic Association. Basic Cartography for students and technicians. London, International Cartographic Association, (1984).

Keller, C.P. "Towards an Introductory Cartographic Curriculum for the 21st Century." Cartographica 33(3): 45-51, (1996).

Kirman, Joseph. Elementary School Studies, Toronto, Allyn and Bacon, (1996).

Muehrcke, Philip and Joanna Muehrcke. Map Use: reading, analysis and interpretation. Madison, Wisconsin, JP Publications, (1998).

National Centre for Geographic Information Analysis Core Curriculum in GI Science. August 13, 2000. National Centre for Geographic Information Analysis. August 8, 2002 <http://www.ncgia.ucsb.edu/education/curriclula/giscc>

Ormeling, F. J., and R.W. Anson & ed. Basic Cartography for students and technicians. London, Elesvier Applied Science Publishers, (1993).

Plotnick, Eric. "Definitions and Perspectives." Teacher Librarian 28(1): 27-29, (2000).

Rabenhost, T., and Paul McDermott. Basic Cartography. Columbus, Merrill Publishing, (1989)

Rabenhost, T., and Paul McDermott. Applied Cartography: Source Materials for Mapmakers. Columbus, Merrill Publishing, (1989)

APPENDIX TWO – INITIAL LIST OF CONCEPTS AND ABILITIES

Traditional Map Concepts and Abilities

Thematic and Topographic Map

- Ability to understand how to read various types of thematic maps
- Ability to identify visual patterns on a thematic map
- Ability to specify locations using co-ordinate systems on the map (i.e. Lat/long and UTM)
- Read elevations form contours
- Ability to identify symbols using legends

Scale

- Ability to understand and state scale as a representative fraction, a verbal scale and a visual scale.
- Ability to measure distance-using scale stated on a map.

Map Projections

- Ability to understand the general properties of map projections:
- Conformality, equivalence, distance, and direction
- Ability to awareness of commonly used map projections

Grids

- Ability to locate objects on a grid

Co-ordinate Systems

- Ability to locate objects and features using lat/ long.

Cardinal Directions

- Ability to use cardinal directions to take a bearing
- Ability to measure direction in reference to four cardinal directions
- Ability to use a compass
- Ability to plan a route using a compass

Bearings i.e. Magnetic vs. Grid

- Ability to calculate a magnetic bearing
- Ability to calculate a grid bearing

Map Analysis

- Ability to calculate slope and vertical profiles
- Ability to create contour lines from spot elevations

Location

- Ability to create a mental maps of your surrounding

Symbols and Legends

- Ability to design appropriate features for symbols

Cartographic Design

- Ability to design and create a map (including legends scale, north arrow, etc.).
- Ability to create a map utilizing concepts such as: figure ground, colour theory and text placement
- Ability to construct flow maps, cholorpleth and proportional symbol maps

Traditional Sources of Geographic Information.

Analog Sources

- Ability to search and locate geographic information within a library

Aerial Photographs

- Understanding of the capture, processing and application of viewing of aerial photos
- Ability to calculate the scale, flying height of an aerial photo.

Numbers and Calculations

- Ability to calculate distance on map using its stated map scale

Area

- Ability to calculate the area of features on a map

Heights

- Ability to calculate the height of features using a topographic map.

Unit conversions

- Ability to convert between various units of measurement i.e. metric to imperial
- Ability to calculate non-linear areas
- Ability to calculate bearings from map references

Geometry

- Ability to locate objects using Cartesian co-ordinates
- Ability to calculate distances between points

Trigonometry

- Ability to use Pythagoras Theorem

Descriptive Statistics

- Ability to calculate mode, mean and median
- Ability to calculate variance and standard deviation

Sources of Digital Geographic Information

- Ability to properly digitize a paper map.
- Ability to fix digitizing errors
- Ability to scan paper maps
- Ability to geo-reference a digital map
- Ability to collect positional information using a GPS Receiver
- Ability to process GPS information into a useable format

Digital Mapping Skills

Digital Sources

- Ability to search the internet for sites relating to geographic information
- Ability to access online and electronic atlases
- Ability to use imagery (i.e. landsat and radarsat)
- Ability to re-projecting of geographic information
- Ability to shifting datums of geographic information.

Creating Metadata

- Ability to utilize metadata, which accompanies geographic information
- Ability to properly document geographic information, aware of elements of metadata (i.e. data quality, error propagation, spatial reference information and the spatial data organization)

Data Quality

- Assess information for currency, completeness and cost.
- Know the difference between accuracy and precision

Error propagation

- Identify how errors propagate through a dataset
- Understand how errors can propagate through a dataset

Spatial Reference Information

- Ability to identify the map projection of a digital map

Co-ordinate Systems

- Ability to identify the co-ordinate system of a digital map

Datums

- Ability to identify the horizontal and vertical datum of a digital map

Spatial Data Organization

- Understand the difference between Raster and Vector

Non-spatial Database design
- Ability to build a relational database
- Ability to build an object-oriented database
- Ability to design and populate a database

Attribute Information
- Ability to recognize primary and secondary information.
- Ability to recognize quantitative vs. qualitative
- Ability to apply levels of measurement geographic information
- Ability to query a database using standard query language

Information Organization and Analysis
- Ability to organize information to permit analysis
- Ability to understand which analysis methods correspond with the information you are working with.

Law of Transformations
- Ability to utilize a generalization algorithm to generalize a feature

Spatial Analysis
- Ability to conduct spatial overlay
- Ability to construct a buffer
- Ability to spatial Allocation
- Ability to use map algebra with the appropriate information
- Ability to develop a terrain model using the appropriate information
- Ability to geo-code a network
- Ability to use a use a geo-coded network

Presentation of Information
- Ability to design a Website
- Demonstrate an understanding of charting and graphing
- Create virtual reality and multi-media

Geographic Information Management Issues
- Know how to properly implement geographic information system;
- Understand the role of geo-technologies in society;
- Understand the ethical, legal and socio-economic issues surrounding information and information technologies;
- Awareness of the limitations of information gathering tools or strategies and the conclusions drawn from these tools; and
- Define a realistic overall plan and timeline to acquire the needed information

APPENDIX THREE - K-12 GEOGRAPHIC INFORMATION LITERACY QUESTIONNAIRE

Introduction

The purpose of this questionnaire is to give the geographic information community an opportunity to express opinions about which geographic information concepts and abilities are essential for students at the K-12 level. This questionnaire is separated into two parts.

Part One
This part of the questionnaire asks for you to comment on a list of geographic information concepts and abilities we have compiled. You are asked to review the list of concepts and abilities and rank items in terms of their importance.

Part Two-Open Response
This is an opportunity for you to let us know which geographic information concepts and abilities you think students should possess by the time they leave high school.

Click here to view the consent rules and regulations governing this questionnaire

Part One

Instructions

Below are two lists of concepts and abilities relating to the usage of geographic information. One list is for digital geographic information, the other is for traditional geographic information. These lists are by no means complete. We have tried our best to include as much as possible, but we have surely missed something or we have added too much. This is where we need your help!!

First, please review the following list of concepts and ability. Concepts are listed in bold. Underneath each concept are related abilities.

Click here for details about the construction of this list

Second, after reviewing the list, give us your input about which concepts and abilities you believe are essential for students at the K-12 level. When ranking these concepts and abilities, keep in mind how teaching a particular concepts or ability would improve a student's understanding of geographic information. The ranking system is as follows:

- essential
- important
- optional
- not important
- not appropriate

Click here to view the consent rules and regulations governing this questionnaire

Traditional Map Concepts and Abilities

Components of Traditional Maps

Concept: Scale
Ability one:
Understand how to state scale in its various formats (i.e. representative fraction, verbally, or visually).

Concept: Resolution
Ability one :
Comprehension of how resolution affects the level detail in geographic information.

Ability two:
Understand how to select maps with appropriate resolution.

Concept: Map Projections
Ability one:
Understand how to select and define a map projection and their properties (i.e.conformality, equivalence, distance, and direction).

Concept: Geodetic Datum
Ability one:
Comprehension of the concept of geodetic datums and the ability to select the correct geodetic datum.

Concept: Reference Ellipsoids
Ability one:
Familiarity with the concept of reference ellipsoids.

Concept: Coordinate Systems
Ability one:
Understand how to locate objects on a Cartesian grid.

Ability two:
Understand how to locate objects and features using latitude/longitude

Ability three:
Understand how to locate objects and features using UTM.

Concept: Directions
Ability one:
Understand how to use cardinal directions to take a bearing.

Ability two:
Understand how to use a compass.

Ability three:
Recognize the difference between true north, magnetic north and grid north.

Concept: Symbols and Legends
Ability one:
Ability to design appropriate symbols for features on a map.

Ability two:
Understand conventions and rules for design and selection of symbols and legends

Concept: Cartographic Design
Ability one:
Understand the design process, including hands on experience.

Ability two:
Familiarity with map design concepts such as: figure ground, colour theory and typonomy.

Ability three:
Understand how to select and produce different types of thematic maps (i.e. flow maps, choropleth and proportional symbol maps).

Concept: Map Reading and Understanding
Ability one:
Understand how to measure direction in reference to four cardinal directions.

Ability two:
Ability to identify visual patterns on a thematic map.

Ability three:
Understand how to specify locations using coordinate systems on a topographic map (i.e. Lat/long and UTM coordinates).

Ability four:
Obtain elevations by reading contours.

Ability five:
Ability to obtain information by reading symbols on a map.

Traditional Sources of Geographic Information

Concept: Analog Sources
Ability one:
Successfully search for geographic information within a library.

Ability two:
Understand how to interpret metadata associated with paper maps.

Concept: Aerial Photographs
Ability one:
Familiarity with the capture and usage of aerial photographs.

Ability two:
Understand how to read and interpret aerial photographs.

Map Related Calculations

Concept: Distance
Ability one :
Calculate distance on map using its stated scale.

Ability two:
Calculate distances between points on a map.

Concept: Area
Ability one:
Calculate the area of features on a map.

Concept: Heights
Ability two:
Calculate the height of features using a topographic map.

Concept: Unit Conversions
Ability one:
Successfully convert between units of measurement i.e. metric to imperial.

Concept: Descriptive Statistics
Ability one:
Calculate and understand mode, mean and median.

Ability two
Calculate and understand variance and standard deviation.

Concept: Bearings
Ability one
Calculate a magnetic bearing.

Ability two
Calculate a grid bearing.

Concept: Slope and Vertical Profiles
Ability one:
Calculate slope and build vertical profiles.

Ability two:
Derive contour lines from spot elevations.

Concept: Scale of an Aerial photo
Ability one:
Understand how to calculate the scale, and/or the flying height of an aerial photographs.

Digital Map Concepts and Ability

Components of Digital Mapping

Concept: Spatial Data Organization
Ability one:
Understand the difference between Raster and Vector data.

Ability two:
Familiarity with object oriented data structures.

Ability three:
Familiarity with spatial data ontologies.

Concept: Non-spatial Database Design
Ability one:
Demonstrate an ability to design and populate an attribute database.

Concept: Attribute Information
Ability one:
Understand the difference between primary and secondary information.

Ability two:
Understand the difference between quantitative and qualitative information.

Ability three:
Familiarity with different levels of measurement (nominal, ordinal, interval and ratio).

Ability four:
Understand the difference between absolute and derived data.

Concept: Metadata
Ability one:
Understand how to utilize metadata accompanying geographic information.

Ability two:
Understand how properly to document geographic information, keeping in mind the elements of metadata. (i.e. data quality, error propagation, spatial reference information and the spatial data organization)

Concept: Data Quality
Ability one:
Understand how to assess information for currency, completeness and cost.

Ability two:
Understand how to differentiate between accuracy and precision.

Ability three:
Understand how to document changes which have been made to a geographic information dataset.

Concept: Error propagation
Ability one:
Understand how errors can propagate through a dataset.

Concept: Spatial Reference Information
Ability one:
Understand how to Identify the projection of a digital map.

Ability two:
Understand how to identify the coordinate system of a digital map.

Ability three:
Ability to identify the horizontal and vertical datum of a digital map.

Concept: Information Organization and Analysis
Ability one:
Understand how to manipulate information to facilitate analysis.

Ability two:
Understand how to select an analysis methods suitable to your information.

Concept: Amalgamating existing sources of geographic information
Ability one:
Understand how to re-project geographic information.

Ability two:
Understanding how to shifting datums of geographic information.

Concept: Spatial Analysis
Ability one:
Understand how to conduct a spatial overlay

Ability two:
Understand how to construct a buffer

Ability three:
Understand and know how to use map algebra.

Ability four:
Understand how to develop a terrain model.

Ability five:
Familiarity with network analysis.

Ability six
Understand the uses of network analysis.

Concept: Presentation of Digital Information
Ability one:
Understand different types of thematic mapping options

Ability two:
Demonstrate an ability to present results as a website.

Ability three:
Understand the proper uses of charts and graphs.

Concept: Geographic Information Management Skills
Ability One:
Understand copyright and ownership issues associated with geographic information.

Ability two:
Understand how geo-technologies are being used in society.

Ability three:
Understand the ethical, legal and socio-economic issues surrounding geographic information and information technologies.

Ability four:
Understand the limitations of geographic information gathering tools or strategies and the conclusions drawn from these tools.

Ability five:
Understand how to create a realistic working plan and timeline to acquire needed information.

Sources of digital geographic information

Concept: Digitizing and Scanning
Ability one:
Understand how to scan a paper map.

Ability two:
Understand how to digitize a paper map.

Ability three:
Understand how to fix digitizing errors.

Ability four:
Understand how to geo-reference a digital map or image.

Concept: Global Positioning Systems
Ability one:
Understand how to collect positional information using a GPS Receiver.

Ability two:
Understand how to process GPS information into a useable format.

Concept: Internet Sources
Ability one:
Understand how to search the Internet for geographic information.

Concept: Satellite Imagery
Ability one:
Understand how to use imagery such as Landsat and Radarsat.

Personal Information

Before moving on to the optional second part of this survey, would you mind offering us the following personal information. If you are uncomfortable with any of these questions, please feel free to skip it and move on to the next question.

1. What is your highest level of education?
   High School, Technical Diploma, BA, BSc, MA, MSc, PhD.

2. What is your occupation?
   Education, Industry, Government

3. What is your gender?
   Male Female

4. In which country are you currently living?
   (If you are living in Canada or the United States please specify your state or province)

5. What year were you born?

6. Currently, do you have children in the education system? Yes No

7. If yes, how many children do you have in the education system

8. What grade(s) are your children are you in?

We are aware that considerable research already has been undertaken investigating GIL in the K-12 Curriculum. Click here for a bibliography of reports, papers and URL's we have come across. Feel free to use this bibliography. Are you aware of any information sources (reports, papers, URLs, …) that we have missed?

If yes, and you are willing to share that source, please specify the reference(s) in the text box below or e-mail the references independently to Jason's e-mail.

In the space below give us your comments about our questionnaire

Are you are interested in receiving a summary of the results of this survey?
Yes, please specify an e-mail address

Your anonymity is protected as you are not requested or required to provide your name in order to participate in the survey. You will not be contacted in the future unless you request a summary of the results of this study emailed to you, in which case you need only to provide your e-mail address. Your e-mail address will not be used for any other purpose, nor will it be sold to any individual or organization

Thank-you for participating in this research questionnaire.

Please press to complete the first part of this questionnaire.

Appendix Four - Complete List of Closed Questionnaire Results

#	Concept or Ability	Mode	Range	Mean
1	Understand how to state scale in its various formats (i.e. representative fraction, verbally, or visually).	3	2	2.6
2	Comprehension of how resolution affects the level detail in geographic information.	2	2	2.2
3	Understand how to select maps with appropriate resolution.	2	2	2.0
4	Understand how to select and define a map projection and their properties (i.e.conformality, equivalence, distance, and direction).	2	2	2.0
5	Comprehension of the concept of geodetic datums and the ability to select the correct geodetic datum.	1	2	1.6
6	Familiarity with the concept of reference ellipsoids.	1	2	1.5
7	Understand how to locate objects on a Cartesian grid.	3	2	2.5
8	Understand how to locate objects and features using latitude/longitude	3	2	2.7
9	Understand how to locate objects and features using UTM.	1	2	1.9
10	Understand how to use cardinal directions to take a bearing.	3	2	2.3
11	Understand how to use a compass.	2	2	2.2
12	Recognize the difference between true north, magnetic north and grid north.	2	2	2.3
13	Posses an ability to design appropriate symbols for features on a map.	2	2	2.1
14	Understand conventions and rules for design and selection of symbols and legends	2	2	1.9
15	Understand the design process, including hands on experience.	2	2	1.9
16	Familiarity with map design concepts such as: figure ground, colour theory and typonomy.	1	2	1.7
17	Understand how to select and produce different types of thematic maps(i.e. flow maps, choropleth and proportional symbol maps).	2	2	2.0
18	Understand how to measure direction in reference to four cardinal directions.	3	2	2.6
19	Ability to identify visual patterns on a thematic map.	3	2	2.4
20	Understand how to specify locations using coordinate systems on a topographic map (i.e. Lat/long and UTM coordinates).	3	2	2.5
21	Obtain elevations by reading contours.	3	2	2.4
22	Ability to obtain information by reading symbols on a map.	3	2	2.6
23	Successfully search for geographic information within a library.	2	2	2.3
24	Understand how to interpret metadata associated with paper maps.	2	2	2.0
25	Familiarity with the capture and usage of aerial photographs.	1	2	1.5
26	Understand how to read and interpret aerial photographs.	1	2	1.7
27	Calculate distance on map using its stated scale.	3	2	2.7
28	Calculate distances between points on a map.	3	2	2.6
29	Calculate the area of features on a map.	2	2	1.9
30	Calculate the height of features using a topographic map.	2	2	2.0
31	Successfully convert between units of measurement i.e. metric	3	2	2.2
32	Calculate and understand mode, mean and median.	2	2	2.0
33	Calculate and understand variance and standard deviation.	1	2	1.6
34	Calculate a magnetic bearing.	1	2	1.6
35	Calculate a grid bearing.	1	2	1.7

#	Concept or Ability	Mode	Range	Mean
36	Calculate slope and build vertical profiles.	2	2	1.7
37	Derive contour lines from spot elevations.	1	2	1.6
38	Understand how to calculate the scale, and/or the flying height	1	2	1.6
39	Understand the difference between Raster and Vector data.	1	2	2.0
40	Familiarity with object oriented data structures.	1	2	1.7
41	Familiarity with spatial data ontologies.	1	2	1.6
42	Demonstrate an ability to design and populate an attribute	2	2	1.8
43	Understand the difference between primary and secondary	3	2	2.3
44	Understand the difference between quantitative and qualitative information.	3	2	2.4
45	Familiarity with different levels of measurement (nominal, ordinal, interval and ratio).	2	2	1.9
46	Understand the difference between absolute and derived data.	2	2	1.9
47	Understand how to utilize metadata accompanying geographic	1	2	1.9
48	Understand how to properly document geographic information	2	2	1.8
49	Understand how to assess information for currency,	2	2	2.0
50	Understand how to differentiate between accuracy and precision.	2	2	1.9
51	Understand how to document changes which have been made to a geographic information dataset.	1	2	1.8
52	Understand how errors can propagate through a dataset.	2	2	2.0
53	Understand how to Identify the projection of a digital map.	2	2	1.9
54	Understand how to identify the coordinate system of a digital	2	2	2.1
55	Ability to identify the horizontal and vertical datum of a digital map.	2	2	1.7
56	Understand how to manipulate information to facilitate analysis.	2	2	1.9
57	Understand how to select an analysis methods suitable to your	2	2	1.9
58	Understand how to re-project geographic information.	1	2	1.7
59	Understanding how to shifting datums of geographic	1	2	1.5
60	Understand how to conduct a spatial overlay	1	2	1.8
61	Understand how to construct a buffer	2	2	1.6
62	Understand and know how to use map algebra.	1	2	1.5
63	Understand how to develop a terrain model.	1	2	1.4
64	Familiarity with network analysis.	1	2	1.4
65	Understand the uses of network analysis.	1	2	1.5
66	Understand different types of thematic mapping options	1	2	2.0
67	Demonstrate an ability to present results as a website.	1	2	1.7
68	Understand the proper uses of charts and graphs.	3	2	2.3
69	Understand copyright and ownership issues associated with	2	2	2.0
70	Understand how geo-technologies are being used in society	2	2	2.2
71	Understand the ethical, legal and socio-economic issues	2	2	1.9
72	Understand the limitations of geographic information gathering tools or strategies and the conclusions drawn from these tools.	2	2	2.0
73	Understand how to create a realistic working plan and timeline to acquire needed information.	1	2	1.7
74	Understand how to scan a paper map.	2	2	1.9

#	**Concept or Ability**	**Mode**	**Range**	**Mean**
75	Understand how to digitize a paper map.	2	2	1.7
76	Understand how to fix digitizing errors.	2	2	1.8
77	Understand how to geo-reference a digital map or image.	2	2	1.8
78	Understand how to collect positional information using a GPS	2	2	1.8
79	Understand how to process GPS information into a useable format.	2	2	1.8
80	Understand how to search the Internet for geographic information.	3	2	2.2
81	Understand how to use imagery such as Landsat and Radarsat.	1	2	1.6

VITA

Surname: Miller **Given Names**: Jason Allen

Place of Birth: Vancouver, British Columbia, Canada

Educational Institutions Attended:

Simon Fraser University	1998 to 2000
Langara College	1995 to 1998

Degrees Awarded:

B.A.	Simon Fraser University	2000
Certificate in Spatial Information Systems	Simon Fraser University	2000

Honours and Awards:

Sara Spencer Research Scholarship	2001

UNIVERSITY OF VICTORIA PARTIAL COPYRIGHT LICENSE

Title of Thesis/Dissertation:

Geographic Information Literacy in British Columbia's K-12 Education Curriculum

Autho[redacted]
Jason [redacted]

January 3, 2004

VITA

Surname: Miller **Given Names**: Jason Allen

Place of Birth: Vancouver, British Columbia, Canada

Educational Institutions Attended:

Simon Fraser University	1998 to 2000
Langara College	1995 to 1998

Degrees Awarded:

B.A.	Simon Fraser University	2000
Certificate in Spatial Information Systems	Simon Fraser University	2000

Honours and Awards:

Sara Spencer Research Scholarship	2001

Title of Thesis/Dissertation:

Geographic Information Literacy in British Columbia's K-12 Education Curriculum

Author [redacted]
Jason Allen Miller

February 23, 2004