Geomatics Curriculum Development

Final Report

Geospatial Knowledge Areas and Concepts Across the Ontario Curriculum

by

Bob Sharpe, PhD
Department of Geography and Environmental Studies
Wilfrid Laurier University
Waterloo, Ontario

Niem Tu Huynh, MES
Waterloo-Laurier Graduate Program in Geography

A research project partially funded by the
GeoSkills program of Natural Resources Canada

With the

Department of Geography and Environmental Studies
Wilfrid Laurier University
Waterloo, Ontario

As represented by:

Bob Sharpe, PhD
Department of Geography and Environmental Studies
Wilfrid Laurier University
Waterloo, Ontario
N2L 3C5

March 29, 2005

Telephone: 519-884-1970
Fax: 519-725-1342

Email: bsharpe@wlu.ca

Wilfrid Laurier University, Department of Geography and Environmental Studies website:
http://www.wlu.ca/~wwwgeog/

Geomatics Curriculum Development

Final Report

Geospatial Knowledge Areas and Concepts

Across the Ontario Curriculum

TABLE OF CONTENTS

V Conclusions and Recommendations

References

Appendices

List of Figures

I Introduction

Goals and Objectives

The goals of this research are to investigate the presence of geospatial knowledge areas and concepts within Ontario's K-12 curriculum, and to identify opportunities for their further integration across the curriculum. This paper reports on the overall results of a two-part research project. Phase one developed the method of analysis and used the social studies and geography curriculum from kindergarten through grade 12 as its focus. Phase two extends the analysis to include other subject areas outside geography's domain, such as business, health and physical education, history, mathematics, native studies, science, social science and technology.

The objectives of the research are:

- to generate an ordered set of fundamental geospatial concepts;
- to develop simple techniques to search for these geospatial concepts in the geography curriculum documents;
- to identify the learning expectations and activities in the geography curriculum documents that are related to the geospatial concepts;
- to analyze the representation of geospatial concepts by their occurrences in the geography curriculum
- to identify occurrences of geospatial concepts in the non-geography curriculum
- to identify and report on the learning expectations and activities in the non-geography curriculum that are related to the geospatial concepts
- to provide a foundation for the development of a standards-based Geomatics Curriculum Framework.

Project Description

The scope of this research is limited to a basic practical purpose which is to identify opportunities for integrating geospatial concepts and skills across the Ontario curriculum. It does not address questions about cognitive development nor educational theory to be considered in the design of age-appropriate geomatics curricula. It discusses what we need to know about spatial thinking only in terms of what educators and the curriculum currently state. It does not address how the capacity for spatial thinking develops and how might it be fostered systematically by education and training.

This section of the report first outlines the properties of geospatial knowledge and then describes the current status of geospatial concepts and skills in the Ontario curriculum.

Geospatial Knowledge Areas

Geospatial information refers to spatial data relating to the Earth. Spatial data have at least two coordinates specified to define a location, (e.g. x/y, or latitude and longitude). Associated with that location is often a third dimension (e.g. elevation or other attribute), and a fourth dimension (time). Not only is it multidimensional, but geospatial information must often be projected onto a flat surface. As a result, understanding geospatial information involves specialized concepts (e.g. map projections) and its analysis requires special skills and methods (e.g. topological analysis). The set of concepts and skills needed to understand and work with geospatial information is known, in this report, as Geospatial Knowledge.

What knowledge of geospatial information a student should have, and at what levels, is of interest to geomatics educators. This research examines the geospatial knowledge expected in kindergarten through grade 12, although the focus is primarily on the curriculum offered at the secondary level in grades 9, 11, and 12. It's at these levels where most geospatial concepts (ideas that form knowledge) can be expected. But, what geospatial knowledge is expected of a grade 9 student, in other words of every high school graduate in Ontario? What geospatial knowledge is expected of students that specialize in geography in grades 11 and 12? What knowledge is expected in other subjects that use, or could use, geospatial information, such as math, science, history or business?

Thus, it is important to research what geospatial knowledge is expected in subjects across the curriculum. This involves first identifying the geospatial knowledge areas and concepts that are appropriate to learn at the K-12 level. Once a list of concepts has been established it is then possible to use computer-assisted techniques to search for their occurrence in any curriculum document, and to examine how they are incorporated into the learning expectations of other subjects.

Current Geomatics Curricula in Ontario

Geospatial concepts and skills have a strong place in the Ontario curriculum. They have a solid foundation at the elementary level in the social studies curriculum, and they have a significant role in Grade 9 course, which is required of all students. For students interested in studying geomatics in more depth there are two specialized elective courses in grades 11 and 12.

Elementary School Curriculum

In the Ontario curriculum geospatial concepts and knowledge are presented under the more general rubric of Social Studies in Grades 1 through 6. At this level the focus on social studies is on Heritage and Citizenship, and Canada and World Connections. In Grades 7 and 8 students are required to take specific courses in both History and Geography. Geography in Grade 7 focuses on 'The Themes of Geographic Inquiry, Patterns in Physical Geography, Natural Resources'. In Grade 8 the focus shifts to 'Patterns in Human Geography, Economic Systems and Migration'. Throughout the Grades 1 to 8 curriculum students are assessed in four strands of expected knowledge and skills:

· Understanding of concepts

· Inquiry/research skills and map and globe skills
· Communication of required knowledge
· Application of concepts and skills

One strand of expectations is dedicated specifically to 'Inquiry/research skills and map and globe skills'. Each of the expectations within the elementary curriculum relating to geospatial ideas are listed in Table 1. These expectations are cumulative, which is to say that they are first introduced at the specified grade level and then reinforced in subsequent grades. The concept of scale is introduced as early as Grade 1, and most mapping expectations are in Grades 2 and 4.

Secondary School Curriculum - Canadian and World Studies

In Grades 9 to 12 of the Ontario curriculum, geography is included through an integrated program of study called Canadian and World Studies which encompasses five subjects: economics, geography, history, law, and politics. This program builds on two compulsory courses: Grade 9 Geography of Canada, and Grade 10 Canadian History in the Twentieth Century, (as well as a half-credit course in Civics). The Grade 9 course incorporates a significant component in its learning expectations. Following this are nine geography electives available to students: 4 courses in Grade11 and 5 courses in Grade 12.

Within the Canadian and World Studies program the content relating to geomatics is included in two different ways:

· There are five strands of learning expectations in the Canadian World Studies program that are common to geography courses in Grades 9 through 12. One of these strands is Methods of Geographic Inquiry in which students are expected to become familiar with a broad range of new and traditional techniques and approaches including mapping, aerial photograph interpretation, remote sensing, image analysis, GPS, and GIS.

· There are two courses that specifically focus on geomatics: Grade 11 Geographics: The Geographer's Toolkit; and Grade 12 Geomatics: Geotechnologies in Action. The richness of the overall learning expectations of these courses is exemplified by the list for the Grade 12 course, as shown on Table 2. Both these courses have even more specific expectations which directly relate to map understanding, skill development, and application. Readers interested in this level of detail should consult the course profiles at http://www.curriculum.org/occ/profiles/12/12canwldp.htm (March, 2005)

Overall, the Ontario curricula have both general learning expectations, as well as two senior courses, dedicated to geospatial concepts and skills. It must be noted, however, that there are critical issues concerning the capacity of the schools to offer and successfully deliver the geomatics curricula. There are large variations among teachers, schools and school boards in hardware, training, resources, and support and thus in the ability to offer geomatics to students. These variations constitute a significant obstacle to the effective delivery of geospatial knowledge but are not the subject of analysis in this report.

Outside of Ontario, there have been several recent initiatives attempting to promote the broader integration of geospatial knowledge across the breadth of the geography curricula in Canada. One of

these is the Canadian National Standards for Geography. (Canadian Council for Geographic Education, 2001).

Another initiative, sponsored by Geoconnections Canada, is the Geomatics for High School Curriculum, Ontario, Canada (Geoconnections Canada, 2000). This project consists of Internet distributed geography lessons available in French and English for grades 9 to 12 that meet Ontario High School curriculum standards. The lessons were designed to be conveniently adapted to the curriculum requirements of other provinces.

Although useful, these and other efforts have been directed primarily at helping teachers to more effectively use geomatics in the delivery of the current geography and environmental studies curricula. Very little attention, however, has been given to opportunities for integrating geospatial knowledge outside the domain of geography in other subject areas.

Secondary School Curriculum – Other Subjects

A second approach to the integration of geospatial knowledge into the curriculum is to link it broadly to other subjects. In other words, to include geospatial concepts in courses other than social studies and geography, and the specialized courses in geomatics. Curriculum developers have recognized this potential and incorporated expectations related to geomatics, typically as optional activities, in other grade 11 and 12 geography courses. However, geospatial knowledge has not been incorporated as explicit expectations in courses beyond geography. This is not to suggest that teachers in other disciplines can not and do not use geospatial concepts and knowledge. For example, history teachers use GIS to create maps and animations of settlement processes and historic battles. Similarly, English teachers use maps to better understand literature by visualizing the spatial activity of characters and the landscapes and settings in which they exist. Only a few such teachers, however, have the multi-disciplinary knowledge and skills to successfully teach another subject using geospatial concepts and knowledge. Consultations with the teachers indicate that they are unlikely to adopt learning activities related to geomatics unless they are clearly designed to help achieve the learning expectations of the curricula they are mandated to teach. Hence it is important to first identify the courses that already have learning objectives and expectations that incorporate some reference to geospatial concepts and skills.

II Methods – Phase I

The main research questions of Phase I were: What geospatial knowledge areas and concepts are necessary in the K-12 curriculum? Can a content analysis of the curriculum documents identify learning expectations related to geospatial knowledge?

The research method had four major components: the generation of a list of geospatial knowledge areas and concepts; the review and selection of specialized software for undertaking content analysis; consultations with teachers; and the content analysis of the curriculum documents. Each of these components is described below.

Geospatial Knowledge Areas and Concepts

The first component of the method was to review recent literature in order to generate a list of geospatial concepts and skills. Two documents were of greatest help in creating the initial lists and provided useful insights in developing an analysis of geospatial concepts in the Ontario school curriculum.

One source for identifying concepts related to geospatial information was the Strawman Report (2003). This report was produced by the University Consortium for Geographic Information Science (UCGIS) in the United States to provide a comprehensive model of undergraduate curricula for Geographic Information Science (Strawman, 2003). The model is useful for identifying and organizing the key knowledge areas of geographic information science (GIS). Five of the main areas of geospatial knowledge recommended by the Strawman Report are seen as pertinent to the learning expectations of the K-12 curriculum. These are: the conceptualization of space; spatial data models and data structures; spatial data acquisition, sources and standards; exploratory data analysis; and cartography and visualization. Each of these knowledge areas is comprised of fundamental concepts and skills as shown on Figure 1.

Despite the specialized jargon, most of the concepts listed have foundations in the earliest years of learning. For example, an expectation related to the properties of geographic information in the Grade 1 Ontario curriculum is to "demonstrate an understanding of scale, that is, give reasons for using small objects to represent large ones on map". Other concepts, such as the geodetic datum, are more specialised and thus don't appear as part of the curricula until grade 12 or university.

Information on how these various concepts are relevant to the K-12 curriculum in Canada is provided by Miller's (2004) recent thesis on geographic information literacy. Miller (2004) developed a list of concepts related to geographic information literacy, and then used this list to conduct a curriculum content analysis. Both his list of concepts and basic research design informed these same aspects of this research.

Miller's initial list of concepts was derived from literature review of geographic information studies. He then administered a questionnaire to geography educators and geographic information users via online mailing lists[1]. Having collected 80 responses from well established educators across North America, Miller's results constitute a valuable expert sample. Respondents were also asked to add their own concepts, and to rate the concepts from "essential" to "not appropriate". Miller grouped the resultant list of 81 concepts into three categories of geographic information literacy: traditional information, digital geographic information and information literacy. The results from the questionnaire were then used to conduct content analysis of the K-12 curriculum.

These two sources were the basis for creating the initial list of geospatial knowledge areas and concepts used in this research.

[1] CAG – Canadian Association of Geographers, CCA – Canadian Cartographic Association, ACMLA – Association of Canadian Map Librarians and Archivists, NCGE – National Council for Geographic Education, CCGE – Canadian Council for Geographic Education.

Software Review

The second component of the research method was to review some of the practical literature and software for undertaking content analysis of the curriculum documents. The search for appropriate software included talking to researchers and graduate students who were experienced in using this kind of software, reviewing research that used this tool in their analysis, as well as undertaking an internet search.

An internet search was conducted with Google using the keywords 'qualitative analysis' and 'content analysis'. One of the most helpful websites found is entitled 'Content Analysis Guidebook Online', (http://academic.csuohio.edu/kneuendorf/content/). This website provided a detailed list of both qualitative and quantitative software. Each of the software packages summarized on this site was reviewed and if it appeared to fit the research need, more detail was found about the product on its own website. This process yielded 6 potential software packages. Four were chosen for more detailed analysis: NVIVO, N6, Text Analyst and winMax.

The software packages were compared by undertaking a simple content analysis and searching for keywords in two curriculum documents. During this process, each software package was evaluated according to its interface, ease of use, types of summary tables produced, and the level/types/number of analytic capabilities. It was clear that NVIVO and winMax were both comparable in quality. However, NVIVO provided a comprehensive help manual which simplified the learning curve, and it produced superior summary tables. Hence NVIVO was the software chosen to do the content analysis for this project.

Teacher Consultations

The third component of the research method was to consult with teachers to get their advice in extending and refining the list of geospatial concepts that are adaptable and appropriate to the Ontario geography curriculum. This involved two meetings with teachers.

The first consultation was a workshop with geography teachers held during the fall conference of the Ontario Association of Geography and Environmental Educators (OAGEE) at Waterloo on October 29, 2004. Fourteen teachers participated in a workshop entitled: "Exploring Other Curricula with Geo-technologies." Workshop participants were engaged in an open-ended discussion about the key geospatial concepts and techniques that every student should know about geography. They were then presented with a list of core geospatial concepts and skills that have been identified by previous research, i.e. Miller's thesis, and the Strawman Report. A questionnaire was given to each session participant, and the teachers were asked to rank the concepts and techniques as to whether they are 'core', 'supplemental' and 'ideal, but impractical'. Breakout groups were then formed to identify a list of opportunities for integrating selected concepts and techniques by subject areas: history, English, math, biology, chemistry, physics, business, and technology. At the conclusion of the session the teachers were invited to participate in the day long workshop to be held at Wilfrid Laurier University in December, 2004. The results of this first session were helpful in affirming, extending, and rank ordering the initial list of geospatial concepts.

The second consultation with teachers was a day-long workshop with a small group of teachers representing different subject areas. The workshop was held in the Department of Geography and

Environmental Studies at Wilfrid Laurier University from 8:30 am to 4:30 pm on December 3, 2004. The eight teachers represented a range of subject areas including history, English, math, biology, business, and technology. Prior to the event, participants were sent materials on the key geospatial knowledge areas, expectations, concepts and synonyms[2]. The teachers were asked, in a systematic way, to comment on the following questions:

1. Which of the geospatial expectations, key concepts, or synonyms are relevant to teaching your subject area?

2. Do you already teach these geospatial expectations or something similar in your courses? How do you teach these – what kinds of lessons and classroom activities do you do?

3. How might you incorporate the other geospatial expectations or key concepts into your subject area? How might you teach these?

4. Are there other examples of teaching and learning about geospatial information that are not included in the list expectations, concepts and synonyms?

5. Are there opportunities for integrating geospatial knowledge across the curriculum that are not identified in the curriculum documents?

The results of this workshop were helpful in affirming, extending and rank ordering the initial list of geospatial concepts, as well as in developing synonyms for concepts that are appropriate in non-geography subjects. A summary of these findings is provided by **Figure 2: Geospatial Knowledge Areas: Subject Area Synonyms and Examples.**

Curriculum Content Analysis

The fourth component of the research method was to develop a technique for analyzing curriculum documents in order to systematically identify geospatial learning expectations. The documents that were analyzed include:

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

- The Ontario Curriculum: Social Studies, Grades 1 to 6; History and Geography, Grades 7 and 8, 1998 > Ministry of Education / Ministry of Training, Colleges and Universities

- Canadian and World Studies: The Ontario Curriculum, Grades 9 and 10, 1999 > Ministry of Education / Ministry of Training, Colleges and Universities

- Canadian and World Studies: The Ontario Curriculum, Grades 11 and 12, 2000 > Ministry of Education / Ministry of Training, Colleges and Universities

[2] Further details on these materials, the workshop, and the consultation process can be provided on request to the authors.

The objective was to develop a simple technique to search curriculum documents for previously identified geospatial concepts. A further objective was to have the ability to identify the learning objectives and activities related to the geospatial concepts. The basic procedure for undertaking the content analysis includes the following steps:

1. Pre-process document files: reformat files, remove headers, introductory overviews and glossaries, thereby creating a shorter, concise document.
2. Undertake various frequency counts of geospatial concepts.
3. Analyze the meaning of concepts in their context – is the concept geospatial?

Each of these steps is elaborated below:

1. The first step involves preprocessing the curriculum document files. This means converting the documents to a format that can be read by the software (i.e. rich text format, *.rtf, for NVIVO). This file then needs to be edited. First, it needs to be edited to remove titles, section headers, table contents, introductory paragraphs, glossaries and anything that is not part of the general or specific expectations that inflate the frequency count of particular words. Second, the text needs to be edited to remove breaks in sentences or paragraphs. Converted document lose their original formatting, so that the context of a keyword that is reported by the software is only a few words either side rather than the entire sentence or paragraph. This problem arises when converting *.html files to *.rtf, plain text, or any other file.

2. The second step is to undertake frequency counts. The documents being searched can be analyzed separately or in combination. Reports can then be generated that allow for various kinds of comparative analyses among and between documents and concepts.

3. The third step is to examine the segments of text associated with each instance of a reported keyword in order to determine if the concept is used in a geospatial sense. It may take more than neighbouring words around a keyword to put it into context. Hence, it's important to read the keyword within the expectation paragraph to fully understand how it is used.

In developing this procedure it was learned that certain kinds of words, such as verbs, words with multiple meanings, and adjectives are not useful keywords. For example, instead of using the verb 'classify', it's much more useful to use a noun of that verb such as classification. The reason is that classify may appear as a skill for not only geospatial concepts but for a range of other activities. This would then inflate the frequency count of the concept. Words with multiple meaning such as 'form' (as in 'shape' but it can also be used as 'to form an idea') or 'class' (as in 'group these urban areas into difference size classes' or 'allow the class to..') should be avoided because they will give a higher count. Adjectives such as 'absolute', 'visual' should not be searched alone. First, they are too general. Second, it's the noun after it that will put the words into context. For example, 'visual pattern' versus 'visual art'. These two concepts both have the keyword 'visual' but are broadly different. If an adjective is used, it is crucial to include the next word to have full meaning. Plurality may affect the frequency account. The keyword 'maps' will not be found if 'map' was searched. So, it is advisable to search for the singular and plural of a keyword to find all plurality forms of the keyword.

III Methods – Phase II

The main research questions of Phase II were: What geospatial knowledge is present at the 9-12 levels in curricula outside of geography? What are the learning expectations associated with these concepts?

An overview of the research method for this phase is shown on Figure 3. It has 3 major components: the refinement of the list of geospatial knowledge areas and concepts (the search list); the selection and preparation of the curriculum documents; and the quantitative and qualitative content analysis of the selected curriculum documents. Each of these components is described below.

Refinement of the List of Geospatial Knowledge Areas and Concepts

In Phase I, an initial list of 193 concepts was compiled from multiple sources including the Strawman's Report, Jason Miller's Thesis, and discussion between researchers (Dr. Bob Sharpe, Chris Charman and Niem Tu Huynh).

The authors noticed that a few obvious keywords were missing, including 'geography', 'geographic information system' and 'global positioning system.' These were added to the keyword list. A few more geospatial phrases or words from two journal articles (Bednarz ,2004a and 2004b) were added such as "correlate spatial distribution". After an initial NVIVO search of these concepts, the list was distilled to 114 concepts because many were not immediately relevant to geospatial knowledge (e.g. trend), general word (e.g. tabulate). Second, keywords were also eliminated if they were not found in any geography documents. The rationale for this decision is that if the geospatial concept was not found in its home subject geography, it is highly unlikely that it will be found in other subjects.

The list was further reduced to 58 concepts by taking out keywords found in geography courses but had no geospatial meaning. For example, 'accuracy' was used in the context of 'accuracy of' or, 'proportion' was represented as 'proportion of workers'. These 58 concepts were used in the NVIVO to search 160 courses across 8 disciplines.

The list of concepts was further reduced to 34 by compiling only concepts that were found at least once in non-geography courses. The qualitative analysis is based on the findings of these 34 concepts within the Ontario Curriculum.

An initial inspection of the qualitative data (the context of the concept within the curriculum documents) revealed that although the 34 concepts were found within the document, many of the learning expectations were not related to geospatial knowledge. Learning expectations unrelated to geospatial knowledge were removed from further analysis. As a result of this process, several concepts on the list of geospatial knowledge areas that were identified in the documents had connotations unrelated to geography. An example is 'Aspect' which was found 3 times across the curriculum. It was found in a grade 12 course within context of 'a particular aspect of human growth and development'. It was also found in the grade 9 native studies course, as: 'art forms that convey some aspect of Aboriginal peoples' beliefs'. The same was true in grade 9 science, where its context was to: 'describe careers that involve some aspect of reproductive biology'.

In the end, the list of geospatial concepts that unambiguously indicated the presence of learning expectations related to geospatial knowledge consisted of the 22 concepts shown on Figure 4.

Selection and Preparation of the Curriculum Documents

The next part of the analysis involved selecting the curriculum documents to be searched and preparing them for analysis. There are 14 disciplines in the Ontario curriculum, of which eight were chosen for further content analysis, as shown below.

- The Arts
- **Business Studies**
- **Canadian and World Studies**
- Classical and International Languages
- English
- French as a Second Language
- Guidance and Career Studies
- **Health and Physical Education**
- **Mathematics**
- **Native Studies**
- **Science**
- **Social Science**
- **Technological Education**

The eight highlighted streams were chosen for the content analysis for two reasons. First, these subjects were chosen based on their historical linkages to the teaching of Geography in Canadian history. In the 1660s, Geography teaching in Canada included subjects taught by the Jesuits in New France namely, mathematics and philosophy. The second phase of French-Canadian Geography was in 1836 when the Christina Schools in Montreal, introduced Geography manuals. Geography, along with arithmetic, sacred history and geology were taught as one subject. This brief history illustrates that historically, other subjects were taught with or subsumed within geography including mathematics, history (Canadian and World Studies) and geology, giving strong reason to re-examine their current relationships with each other (Tomkins, 1980).

A second reason for focusing on these eight disciplines was based on the advice of teachers. In a one-day workshop with high school teachers, it was discovered through discussion and activities that disciplines with the greatest overlap with geography and potentially geomatics were: Business Studies, Health and Physical Education, Native Studies, Social Science and Technological Education.

The third reason to focus on the eight disciplines was that initial searches revealed relatively few geospatial concepts outside of Canadian and World Studies and Science. The marginal gain in findings was weighed against the time and effort required to do the content analysis, and so it was decided that the remaining five disciplines would not be searched

As previously mentioned, it is entirely possible for teachers of other disciplines, such as Arts, Classical and International Language, English, French, and Guidance and Career to use geospatial

knowledge in their teaching. One can imagine that maps could be of some use in teaching and learning most subjects. But the objective of this research is to identify courses that explicitly mandate the teachers to make reference to geospatial knowledge.

Once the subjects and courses were selected, the course documents were then downloaded from the Internet and pre-processed by reformatting the files and removing titles, headers, and glossaries, as previously explained in the methods section.

Curriculum Content Analysis

The objectives of the content analysis were to search curriculum documents for the previously identified geospatial concepts; and to identify the learning objectives and expectations related to those geospatial concepts. After selecting and preparing the curriculum documents as outlined above, two separate analyses were undertaken.

The first analysis was a frequency count of geospatial concepts undertaken in NVIVO. The output from NVIVO was ported over to a spreadsheet so that reports could be generated that listed the geospatial concepts in rank order of occurrence from the most frequent to least frequent occurrences.

The second analysis involved examining the segments of text associated with each instance of a reported keyword. The purpose was to determine if the concept is used in a geospatial sense. As was learned in Research Phase I, each paragraph or expectation needs to be carefully examined to fully understand how the concept is being used.

IV Findings and Analysis

Geospatial Knowledge Areas and Concepts

A primary outcome of Phase I of this research was the list of 193 geospatial knowledge areas and concepts shown on Figure 1. The figure organizes the concepts in three ways:

- Each concept, such as scale or spatial knowledge, is organized under one of five larger areas of geospatial knowledge: the conceptualization of space, spatial data models and data structures, spatial data acquisition, sources and standards, exploratory data analysis, and cartography and visualization.

- Along with the concepts are synonyms that might be used in subject areas other than geography.

- The concepts are also rank ordered into primary concepts and peripheral concepts. Core concepts are seen to be essential in the K-12 curriculum, while peripheral concepts are not expected to occur, or occur only infrequently in the Grade 11 and 12 curriculum.

Through an iterative process of curriculum content analysis it became clear that many of the keywords were not necessarily related to geospatial concepts, or were problematic in some other ways as explained in the methodology section. The list of keywords to be used in the content analysis of non-geography curriculum documents was further reduced in length so that each

keyword occurrence was a reliable and unambiguous indicator of the presence of a learning expectation related to geospatial knowledge. Eventually it was discovered that only 22 geospatial keywords are found outside of the geography curriculum, as shown by Figure 2.

Quantitative Content Analysis of the Curriculum Documents

This section reports on the results of the quantitative content analysis of the curriculum documents. The results, in the form of frequency counts of the key geospatial concepts, are summarized in three figures, 5-7.

Figure 5 shows the frequency counts of geospatial concepts in the Ontario geography curricula, (grade 1-12), as well as the Canadian Geography Standards. The figure gives a good indication of the emphasis given to different geospatial concepts in the geography curricula. In total the 114 geospatial concepts were mentioned 1,166 times. The concepts are ranked ordered into groups based on similar frequencies of occurrence. The most frequent concepts are those fundamental ideas related to the conceptualization of geographic space: region, place, distribution, spatial, data, location, geography. At the other extreme, there are 13 concepts that do not appear at all in any of the documents: add, angle, arrangement, decomposing, degree, discrete, dispersion, height, orientation, ratio, rule, unit, and visualization.

There were 56 keywords which proved to be effective in identifying pertinent learning objectives, and 58 keywords which were not necessarily related to geospatial concepts (bolded). Not surprisingly, among the most frequently occurring geospatial concepts are direction, distance, latitude, and scale. More general geographic concepts are also common such as region, place, and GIS.

Figure 5 also shows a general trend of an increasing number of concepts being mentioned with each grade. At the elementary level there are 156 occurrences of the 114 geospatial concepts. In the grade 9 course, there are 120 occurrences of these geospatial concepts and in grade 12 there are 339 occurrences of the list. The Standards also have numerous occurrences, at 319. Overall, increasing grade level is accompanied by an increase of geospatial references in the curriculum.

The number of references to particular concepts also varies across grade levels; for example, ‘map’ the most commonly occurring concept appears 8, 5, 14, and 21 times from the elementary grades through grade 9 to grade 12. The frequent use of the concept ‘map’ in the Canadian Geography Standards document explains why it is ranked at the top of the list.

The course which mentions the largest proportion of the 114 concepts is grade 12 geography which includes the Grade 12 Geomatics: Geotechnologies in Action. As previously noted, however, student enrolments in geomatics courses are low because so few schools are able to offer them. Only the grade 9 course is required of all students, and thus is the best indicator of what all students are exposed to, in terms of geospatial knowledge.

Figure 6 shows frequency counts of geospatial concepts in the curricula documents of six non-geography subjects that have the most frequent occurrences.

It is important to note that geospatial concepts were searched in the non-geography courses using a shorter list of concepts (58) than in the geography tables (114).

This figure gives a good indication of the emphasis given to different geospatial concepts outside of the geography curriculum, and in the six subject areas in grades 9, 11, and 12. These are the courses with the most likelihood for finding references to geospatial concepts, and thus this is the key table that directs the search of individual curricula documents for learning objectives and activities related to geospatial knowledge.

Figure 7 shows frequency counts of geospatial concepts in the curricula documents of non-geography subjects that have infrequent occurrences. There are numerous courses and entire subject areas that make little or no reference to geospatial concepts. These included Economics, Social Science, Law, Native Studies, Philosophy, Physical Education, Political Science, and World Religions. These courses are notable for the absence of geospatial concepts; even those concepts mentioned most frequently, such as movement and resolution, are not used as geographic ideas.

Overall, the quantitative analysis was successful in identifying the non-geography courses that are most likely to provide opportunities for further integration of geospatial knowledge. It is these courses that were then analyzed using qualitative techniques.

In terms of the list of 193 geospatial knowledge areas and concepts shown on Figure 1, this analysis of the curricula reveals that the representation of geospatial knowledge areas is limited to some of the most basic core concepts related to the conceptualization of space. A few concepts related to cartography and visualization are also present, but the more specialized concepts related to spatial data models and data structures, spatial data acquisition, sources and standards, and exploratory data analysis are non-existent aside from references to vector data.

Qualitative Content Analysis of the Curriculum Documents

The frequency count is only the start of the analysis. To determine if the concept is associated with a learning objective or expectation it is essential to examine its context within the curriculum documents. For each concept the NVIVO software generated a text file (a coded segment file), in paragraph form, of the learning objective or expectation in which the concept occurs. The learning objectives and expectations were then examined to determine if it was relevant to geospatial knowledge.

Extracting all the learning objectives and expectations linked to geospatial concepts and skills produces a document of 337 pages (Appendix 2: Geospatial Keywords in Context – All Courses). Therefore, to further simplify the analysis, this list of course expectations was subdivided and reduced in length by selecting only learning expectations that appear in non-geography courses. The resultant list of 65 pages of text is given in Appendix 3: Geospatial Keywords in Context – Non-geography Courses.

This appendix was then summarized. The analysis of the non-geography course expectations is recorded in Appendix 4: Non-Geography Courses using Geospatial Concepts. Each concept is

recorded next to the course in which it occurs. Sixty-nine courses incorporate a geospatial concept or skill in their learning expectations.

Twelve courses stand out on this list because there are multiple geospatial concepts and skills incorporated into their learning objectives and expectations: two from each of Business Studies, Canadian and World Studies, and Mathematics, one from the Social Sciences and the Humanities, Mathematics, Native Studies, and Technological Education, and three from Science. It is these courses that provide the greatest opportunities for the further integration of geospatial knowledge into the curriculum. Each of these courses along with their associated geospatial concepts and learning expectations are summarized in Figure 8: Selected Courses with Geospatial Content.

V Conclusions and Recommendations

The work undertaken has generally been successful in achieving the stated objectives of the research project. Below are concluding remarks related to each of the original objectives of the research.

- The first objective was to create an ordered set of fundamental geospatial concepts, based on the literature and teacher consultation. An outcome from Phase I of this project is a comprehensive list of 193 concepts, grouped into core and peripheral (or specialized) knowledge areas, as shown on Figure 1.

    - Figure 1: Geospatial Knowledge Areas

- The second objective was to develop a simple technique of content analysis to search for geospatial concepts in the curriculum documents. A second outcome of Phase I was the decision to use the qualitative analysis software NVIVO and the development of a technique for efficiently identifying keywords and extracting their context.

- The third objective was to identify the learning expectations and activities in the geography curriculum documents that are related to the geospatial knowledge. By reading the course expectations in the Ontario geography curriculum documents became clear that only a small subset of geospatial concepts dominate the curriculum, and that numerous concepts are not mentioned at all. Geospatial concepts in the Ontario Geography Curricula are summarized on Figure 5.

    - Figure 5: Frequency Counts of Geospatial Concepts: Geography Curriculum and Standards

- The fourth objective was to analyze the representation of geospatial knowledge in the geography curricula by examining the frequency with which geospatial concepts occur in curriculum documents. This analysis revealed essentially two domains of geospatial knowledge in the geography curricula: one is related to basic concepts of geography, and the other to still basic, but more specialized geomatics concepts.

- The fifth objective was to analyze the representation of geospatial knowledge in the non-geography curricula. A subset of basic geospatial concepts was used to identify occurrences of concepts across the Ontario curriculum. The analysis included 160 courses in 15 different

subjects that cover 8 disciplines. It was discovered that numerous courses and entire subject areas make little or no reference to geospatial concepts. These included Economics, Social Science, Law, Native Studies, Philosophy, Physical Education, Political Science, and World Religions. Of the non-geography curricula, 6 subjects made relatively frequent reference to geospatial concepts including: Business, Family Studies, History, Math, Science, and Technology.

- Figure 6: Frequency Counts of Geospatial Concepts: Non-geography Curricula with Frequent Occurrences

- Figure 7: Frequency Counts of Geospatial Concepts: Non-geography Curricula with Infrequent Occurrences

- Objective six was to identify and report on the learning expectations in the non-geography curriculum that are related to the geospatial concepts. After a close reading of the course expectations in the curriculum documents, 12 non-geography courses were selected because of their substantial clusters of learning expectations related to the geospatial concepts. These courses and associated learning expectations are reported in detail in Figure 8.

.

- Figure 8: Selected Courses with Geospatial Content

- The final objective was to provide a foundation for the development of a standards-based Geomatics Curriculum Framework. It is recommended that such a framework be pursued in two ways as outlined below.

The findings from this research indicate that geospatial concepts and skills have application across a range of disciplines in the Ontario Curriculum. Several courses have multiple learning objectives in which geospatial concepts are explicit expectations. These specific learning objectives are excerpted from the curriculum documents and reported in Figure 8. It is recommended that for each of these course objectives and expectations, learning activities be prepared that focus on and make explicit the relevant geospatial knowledge. From the teacher workshop, examples of some activities were developed, as shown on Figure 9.

The findings from this research also have implications for a curriculum framework that go beyond the Ontario curriculum. The findings suggest a framework based on two sets of geospatial concepts. One set of concepts is more universal and has relevancy in subject areas outside the domain of geography, while a second set of concepts is more specialized and of relevance primarily to geography students. It is recommended that learning activities be developed for both sets of concepts, independent of any specific curriculum requirements. One set of learning activities would focus on basic conceptualizations of geographic space of interest across a wide spectrum of subjects, such as the concepts of region, place, location, distance, direction, and movement. A resourceful teacher could plug such activities into whatever subject they are teaching. Another set of learning activities would focus on core geospatial concepts of particular interest to geographers, such as position, scale, projection, vector, area and patterns.

Looking ahead to the implementation of ideas arising from this research and to future research, it must be recognized, as the teachers point out, that the only practical way for teachers in other subject areas to teach geospatial concepts would be to combine them with their current activities.

References to geospatial concepts and examples of the application of such knowledge would need to be written into these activities. Consultations with the teachers provided several insights into these and other substantive implementation issues that are outside the purview of this current research. Some issues of implementing changes to the curriculum and of developing new learning activities will be lack of time to integrate geospatial concepts where there is already a tight time schedule to teach the mandatory curriculum expectations. Another problem is the lack of interaction and communication between teachers of different subject areas. Although some of these issues cannot be solved directly, there are solutions, recommended for further research in the next section.

Further Research and Action

1. It is recommended that Geoconnections Canada continue to support research and development in this area. The results of this research provide a good basis for the further development of learning activities for the various geospatial knowledge expectations that have been identified. These can take the form of activity sheets, pool of questions, supplemental teaching materials etc.

2. Undertake further analysis of geography curriculum. Analysis of the geography curriculum documents has shown that many of the 114 geospatial concepts on the keyword list were not identified in the Ontario K-12 geography curriculum. A future research possibility is to identify the geospatial concepts that are absent or under-represented in the different geography curriculum documents. It might be useful to find some way to add these concepts to the documents by using the list of core and peripheral concepts as a guide.

   Which of the key geospatial concepts and skills is poorly developed within the existing curriculum? Where are the gaps? For what key concepts are there few, if any, lesson plans. This will form the basis for rewriting future geography curriculum documents to include more geospatial knowledge.

3. Use current framework as a ‘geodatabase’ to input lesson plans from the Internet. Prepare metadata and criteria based on this project (which is linked to the curriculum). Second, to create a website with explicit links between the geospatial concepts identified here to pertinent lesson plans on various websites (CCGE, Atlas of Canada).

4. Apply the same analyses (quantitative and qualitative) to the recently revised Canadian and World Studies 2005 program to examine what changes if any, geospatial concepts play a role in geography teaching and learning.

5. Careful consideration should be given to the process of implementing geospatial knowledge across the Ontario curriculum because of teachers’ tight time schedule and limited geospatial knowledge. A possible solution is the development of interdisciplinary courses into which geospatial knowledge could be solidly integrated. The development and implementation of such courses is feasible and would offer a number of benefits. It would foster dialogue between geography teachers and teachers of other subject areas. Further, the combined effort will maximize productivity, the efficient use of time and the reinforcement of overlapping concepts across the curriculum. This last action is of

particular important because geography is one of the rare subjects that can fill gaps in between school subjects and disciplines, for example, the Social Sciences and Physical Sciences. Geography is a subject that can make strong contributions to programs because of integrated and interdisciplinary courses (Williams 1992). Geospatial knowledge

References

Bednarz, R. S. and S. W. Bednarz (2004a). “Geography Education: The Glass is Half Full and it's Getting Fuller." The Professional Geographer 56(1): 22-27.

Bednarz, S. W. (2004b). "Geographic Information Systems: A Tool to Support Geography and Environmental Education." GeoJournal 60(2): 191-199.

Canadian Council for Geographic Education (2001). Canadian National Standards for Geography: A Standards_Based Guide to K_12 Geography. http://www.ccge.org/ccge/english/programs/programs_geoStandards.html

GeoConnections Canada (2000). Geomatics for High School Curricula Avaible:http://www.geoconnections.org/CGDI.cfm/fuseaction/projects.projectDetails/id/33/gcs.cfm. Last accessed March, 2005

Miller, Jason A. (2004). Geographic Information Literacy in British Columbia’s K-12 Education Curriculum. Unpublished MA Thesis, University of Victoria, British Columbia.

Neuendorf, Kimberly A. No date. Content Analysis Guidebook Online Available: http://academic.csuohio.edu/kneuendorf/content/. Last accessed December 15, 2004.

Ontario Ministry of Education / Ministry of Training, Colleges and Universities. Available: http://www.edu.gov.on.ca/eng/document/curricul/curricul.html. Last accessed March 2005.

Sharpe, B. and Storie, C. (2002). "Cartography and Geomatics in the High School Curriculum", an unpublished paper prepared following the Annual Conference of the Canadian Cartographic Association/L'Association Canadienne de Cartographie (CCACC), Department of Geography and Environmental Studies, Wilfrid Laurier University.

Tomkins, G. (1980). School Geography in Canada: An Historical Perspective. Canadian Geographical Education. R. Choquette, J. Wolforth and M. Villemure. Ottawa, University of Ottawa Press. **3:** 3-17.

University Consortium for Geographic Information Science (2003). The Strawman Report. Task Force on the Development of Model Undergraduate Curricula.

Williams, M. T. (1992). Geography and Cross-Curricularity. International Perspectives on Geographic Education. A. D. Hill. Skokie, Rand McNally & Company**:** 101-110.

Figure 1: Geospatial Knowledge Areas

CORE KEYWORDS

Knowledge Area 1: Conceptualization of Space

Scale
Representative scale, verbal scale, visual scale, fraction, ratio, proportion

X/Y coordinates
Frame of reference, reference frame, reference system, position, Cartesian grid, chart making, x-axis, y-axis, locate, axis, grid, location

Longitude/Latitude/Locate
Angular distance between an imaginary line parallel to the equator, an imaginary great circle on the surface of the earth passing through the north and south poles at right angles to the equator, locate, place

Direction/Bearing
Focus, vector, cardinal direction, bearing, aspect, angle, slope, orientation, true north, magnetic north, grid north, heading, aim, degree, compass, orientation, aspect

Spatial Knowledge
Area, place, spatial, spatial organization, spatial proximity, region, path, node, landmark, organization charts, location market area

Knowledge Area 2: Spatial data acquisition, sources and standards

Primary information/Secondary information
Primary information, secondary information, collected information, derived information, primary/secondary data/sources

Quantitative and qualitative information
Quantitative information, qualitative information, 'hard' data, 'soft' data, qualitative vs. Quantitative research, demographics

Internet
World Wide Web

Global Positioning System
Navigation system, latitude, longitude, locate, place, track

Accuracy and Precision
Accuracy, precision

Knowledge Area 3: Exploratory spatial data analysis

Measurement, statistics, levels of measurement
Measurement levels, nominal, ordinal, interval, and ratio, rank, place names, size/scale of symbol

Map algebra
Add, subtract, multiply, divide, business math

Measure
Unit, distance, length, benchmark, shortest path, right angle triangle, Pythagorean Theorem, calculator

Calculate Distance
Length, interval, radius, gap, range

Calculate Area
Domain, region, surface area, sphere, unit square, place, space, range

Knowledge Area 4: Spatial data models and data structures

Time
Time, period, life-span, course, term, frequency, era

Knowledge Area 5: Cartography and visualization

Symbols
Denotation, attribute, marker, legend, an arbitrary sign with conventional significance, representation, acronyms

Visual pattern
Clusters, dispersed, linear, randomly distributed

Patterns
Form, shape, design, rule, model, arrangement, trend

Classification
Group, taxonomy, sort, tabulate, arrange, class, analyze, analyze, hierarchy

PERIPHERAL KEYWORDS

Knowledge Area 1: Conceptualization of Space

Resolution
Pixels per square, dpi

Projection
Representation of a figure/solid on a plane as it would look from a particular direction, distance

Universal Transverse Mercator
Location, projection, military grid

Absolute and Spatial Knowledge
Absolute relationship, spatial relationship, 'with respect to', absolute/relative location

Topology
Connectivity, adjacency, enclosure

Knowledge Area 2: Spatial data acquisition, sources and standards

Attribute
Information, attribute database, properties, characteristics, demographics, characteristics, information, data

Absolute data, derived data
Primary and secondary data, input, output, absolute data, derived data

Knowledge Area 3: Exploratory spatial data analysis

Overlay
Boolean operations

Height
Tallness, elevation, vertical dimension, altitude, climax

Knowledge Area 4: Spatial data models and data structures

Continuous and Discrete
Continuous view, discreet view, data, analog representation vs. digital representation

Terrain Model
Terrain model, elevation

Ellipsoid

Ellipse, circle, spheroid, market area

Datum
Measuring benchmark, sea level

Knowledge Area 5: Cartography and visualization

Contour Lines
Elevation, contour, a line drawn on a map connecting points of equal height, profile, relief

Thematic maps
Quantitative maps, statistical maps, choropleth, dot density, graduate symbol, chart maps, cartograms

Figure 2: Geospatial Knowledge Areas: Subject Area Synonyms and Examples

Knowledge Area 1: Conceptualization of space			
#	**Synonyms and phrases**	**Key Words**	**Examples of use in your subject area**
1	representative scale, verbal scale, visual scale, fraction, ratio, proportion	Scale	-Map scales for organization of businesses (i.e. shelf placement)(business) -trigonometry, scale diagrams, scale models, measurement in design, graphing, mixing chemicals/food, floor plans, conversions (math) -magnification, conversion factor, stoichiometry (science) -building of pyramids, using scale/proportion (history) -topographic maps, road map activities (geography) -conversion, floor plan, sewing patterns (family studies) -floor plans, return on investments, supply and demand graphing (Business, Accounting) -technical drawing, ratio automotive gear reductions, mixtures (tech) -mapping skills, intro to atlas (gr. 9 and reviewed in gr. 11/12) (geography)
2	Scale, pixels per square, dpi,	Resolution	-resolving power (science) -computer-info technology (BIT) -pixels/inch, dots/inch, printing monitor resolution (tech) -large scale/small scale maps, when to use (geography)
3	representation of a figure/solid on a plane as it would look from a particular direction, and distance	Projection	-measurement in design, perspective drawings, analytical geometry (math) -molecular modeling, phase of the moon (science) -perspective drawing (art) -small scale vs. large scale map (geography) -orthographic/isometric, photography lenses, technical drawing (tech) -qualities of maps (geography)
4	Frame of reference, reference frame, reference system, position, Cartesian grid, chart making, x-axis, y-axis, locate, axis, grid, location	x/y coordinates	-Survey analysis, demographics (Contemp. Studies) -Survey analysis, market trends (business) -trigonometry, graphing, geometry (math) -graphing (science) -graphs-line, bar; population change over time, topographic map, grid location (geography) -graphing-supply, decrease (Business) -z-axis-animation, machining construction, filmmaking (tech)

			-teaching lat/long to be used in atlas, time zone (geography)
5	Angular distance between an imaginary line parallel to the equator, an imaginary great circle on the surface of the earth passing through the north and south poles at right angles to the equator, locate, place	Locate longitude Latitude	-discussion of different countries around the world (anthropology/Contemp. Studies) -trigonometry (math) -weather, coriolis effect (science) -folktales about how location of a place is reflected in themes/images in stories (public speaking) -maps – label, plot routes from A-B (geography) -time zones, international business (Business) -computer animation, architecture (tech) -grid on topographic map location (geography)
6	Location, projection, military grid	Universal Transverse Mercator Ns	-topographic map -marketing-location of stores (not on grid though, location in difference context) (BBI, BMI) -animation, technical drawing (tech)
7	Focus, vector, cardinal direction, bearing, aspect, angle, slope, orientation, true north, magnetic north, grid north, heading, aim, degree, compass, orientation, aspect	Direction Bearing	-trigonometry, algebra, graphing, measurement in design (math) -kinematics, dynamics, motion (physics) -mapping exercises (geography) -population and food origin, migration (family studies) -curves in graphing (BBI) -demand, supply (economics) -animation, graphic design, video production (heading, pitch, bank (tech)
8	Area, place, spatial, spatial organization, spatial proximity, region, path, node, landmark, organization charts, location market area	Spatial knowledge	-geometry (telling stories from graphs) (math) -astronomy (gr. 9 science) -causes of conflict-regional/place (history) -folktale unite (public speaking) -market/location-retail outlets, marketing (BBI, BMI) -architecture, computer animation (tech)
9	Absolute relationship, spatial relationship, 'with respect to', absolute/relative location	Absolute and spatial relationship	-organization of business space i.e. floor plans (business) -astronomy (gr. 9), kinematics -absolute/relative addressing, computers, manufacturing (tech)
10	Connectivity, adjacency, enclosure	Topology	-architecture (tech)

Knowledge Area 2: Spatial data acquisition, sources and standards			
#	**Synonyms and phrases**	**Key Words**	**Examples of use in your subject area**
1	Primary information secondary information collected information, derived information, primary/secondary data/sources	Primary information, secondary information	-Research skills (Contemp. Studies/Business) -statistics and surveys (math) -investigations in labs (science) -when examining sources/proof (history) -these terms are used in regards to collection and presentation of information (public speaking) -research for ISU (geography and family studies) -marketing-gathering/survey info (marketing) -introduction to business (BMI) -how is data utilized, sample size (emphasized in history)
2	Information, attribute database, properties, characteristics, demographics, characteristics, information, data	Attribute	-demographic identification of groups in society (Contemp. Studies) -periodic table (chemistry, science) -consumers/target market (BBI, BMI) -graphic design, computer graphics, vector based attributes (tech)
3	Quantitative information, qualitative informaiton, 'hard' data, 'soft' data, qualitative vs. Quantitative research, demographics	Quantitative information, qualitative information	-different research methodologies (Contemp. Studies) -different factors of market analysis (Business) -statistics-graphs-interpreting (math) -unit on persuasion, rhetoric (logs/pathos) (public speaking) -qualitative vs. Quantitative (science, all grades) -market/target market data e.g. high income = $70 00 + » (BBI, BMI) -qualitative classification of peoples' landscapes (literature)
4	Absolute data, derived data	Absolute data, derived data, primary and secondary data, input, output	-statistics -investigations/labs (science, all grades) -market research (BBI, BMI) -data in to computer, info out of (BIT) -examine attribute of different ways of manipulating data at methods level (geography)
5	World wide web	Internet	-research tool (Contemp. Studies) -computers, research (Business) -research (math)

			-all (science) -research (public speaking) -ISU research, specific web sites (assignments) (geography) -all business courses -research and design (tech)
6	Navigation system, latitude, longitude, locate, place, track	Global Positioning System	-use ArcView to locate competitors/demographics (Business) -trigonometry, analytic geometry, geometry (math) -weather (gr. 10 science), kinematics (science) -mapping exercises (geography) -mentioned as new technology (BBB) and intro to computers, society users (BIT) -finding site (geography)
7	Accuracy, precision	Accuracy, precision	-accounting (Business) -measurement in design (math) -measurement-all labs esp. in gr. 9 (science) -word choice, information collection and presentation (public speaking) -graphing sales data, supply and demand, data to get market clearing price (Business) -tolerance-manufacturing, resolution-computer graphics (tech) -measurement of distance/scale (geography)
Knowledge Area 3: Exploratory spatial data analysis			
#	**Synonyms and phrases**	**Key Words**	**Examples of use in your subject area**
1	Measurement levels, nominal, ordinal, interval, and ratio, rank, place names, size/scale of symbol	Measurement, statistics, levels of measurement	-survey analysis (Contemp. Studies) -analysis of business health (business) -trigonometry, geometry, statistics (math) -labs and investigations in general (science) -event size, name, impact (history) -mapping-cities/provinces, labelling, size of city population (geography) -investment/return/profit margin (BBI) -graphing intervals (BAF) -tolerance/measurement (how to use tools) (tech)
2	Boolean operations	Overlay	-internet research (Contemp. Studies, Business)

			-spreadsheet software (Business) -data management, algebra (math) -calculations (BBI) -Boolean web search (BAF) -computer electronics programming, animation-geometry construction (tech)
3	Add, subtract, multiply, divide	Map algebra, business mat	-tallying (Contemp. Studies) -ratio analysis, spreadsheet (Business, Accounting, Economic) -everywhere (math) -all (science) -mapping scales, population definition/formulas (geography) -all business courses -construction, architecture, manufacturing, transportation, internet domains (tech)
4	Unit, distance, length, benchmark, shortest path, right angle triangle, Pythagorean Theorem, calculator	Measure	-unit (discussion of survey analysis), demographics (Contemp. Studies) -competition location, business plans (Business) -analytic geometry, trigonometry (math) -all science, especially physics e.g. vector addition (gr. 10) -measuring (Geography) -clothing measurement (Family studies) -distribution of products (BBI) -construction, architecture, manufacturing, transportation, internet domains (tech) -topographic map exercises, inter connections (geography)
5	Length, interval, radius, gap, range	Calculate distance	-surveys (Contemp. Studies) -business plans, target markets (Business) -analytic geometry, statistics (math) -all science -maps (A to B), scale, climate graphs (temperature range) (Geography) -clothing measurement (family studies) -distribution of products, range of income levels, target market (BBI) -construction, architecture, manufacturing, transportation, internet

			domains (tech) -used frequently in geography
6	Domain, region, surface area, sphere, unit square, place, space, range	Calculate area, region location	-floor plans, organization of business space (Business) -functions and relations, geometry (math) -mass/area/volume (chemistry) -maps-cross sections, factors affecting climate, physical features across Canada (geography) - clothing measurement (family studies) -marketing-target markets -domain names -construction, architecture, manufacturing, transportation, internet domains (tech) -used frequently in geography
7	Tallness, elevation, vertical dimension, altitude, climax	Height	-trigonometry, analytic geometry (math) -weather, ecology (gr. 10 science) -all (science) - clothing measurement (family studies) -construction, architecture, manufacturing, transportation, internet domains (tech) -climate change related to altitude (geography)
Knowledge Area 4: Spatial data models and data structures			
#	**Synonyms and phrases**	**Key Words**	**Examples of use in your subject area**
1	Continuous view, discreet view, data, analog representation vs. digital representation	Continuous and discrete	-bar graphs/histograms (math) discrete vs. continuous (all science) -integrated discrete-electronic architecture (tech)
2	Terrain model, elevation	Terrain model	-trigonometry i.e. angles of elevation/angles of depression (math) -ecology, weather (science) -location of ancient towns/villages/model structures (history) -architecture (tech)
3	Time, period, life-span, course, term, frequency, era	Time	-anthropology, studies of difference over time (Contemp. Studies) -business life cycle, product life cycle (Business, Economic) -exponential functions, interest rates (math) -evolution, geology, population growth, history of the university (science)

			-events across time and space (era) (history) -electronics frequency (tech) -population growth, across time and space (geography)
4	Ellipse, circle, spheroid	Ellipsoid, market area	-conics (math) -orbital theories (science) -market area (BBI, BMI) -electronics technical drawing (tech) -sun earth relationship
5	Measuring benchmark, sea level	Datum	-study of the 'norm' (Contemp. Studies) -market averages (Business) -kinematics (gr. 10 science) -motion (gr. 11 physics) -family studies -standards 150 ANSY (tech)
Knowledge Area 5: Cartography and visualization			
#	**Synonyms and phrases**	**Key Words**	**Examples of use in your subject area**
1	Denotation, attribute, marker, legend, an arbitrary sign with conventional significance, representation	Symbols, acronyms	-discussion of cultural symbols and meaning in societies (Contemp. Studies) -creating maps for space organization (Business) -Boolean, inequalities, trigonometry, measurement, patterns, floor plans, legends on graphs (math) -motion i.e. defined directions as positive or negative (physics) -mapping exercises (geography) -cooking, sewing (patterns), housing (floor plans) (family study) -Schematic drawings-architectural drawings (tech) -map making, flow chart, graphs (geography)
2	Elevation, contour, a line drawn on a map connecting points of equal height, profile, relief	Contour lines	-identifying trends (Contemp. Studies, Business) -weather maps (gr. 10 science) -topographic map skills (geography) -architectureal elevations (tech)
3	Clusters, dispersed, linear, randomly distributed	Visual pattern	-Survey results, tallying (Contemp. Studies, Business) -correlations, patterns, graphing (math) -population (gr. 10 ecology, gr. 12 evolution) -development/location of towns/villages/events (history)

			-population patterns (settlement patterns) (geography) -graphing (Business) -classification of areas, landscapes (literature)
4	Quantitative maps, statistical maps, choropleth, dot density, graduate symbol, chart maps, cartograms	Thematic maps	-competitors, demographic (Business) -historical maps (history) -mapping exercise/activities (geography) -population change, maps-food pathways, income levels (family study) -markets, income levels (population density) (BBI, BMI)
5	Form, shape, design, rule, model, arrangement	Patterns, trend	-analyzing trends (Contemp. Studies, Business) -patterning and graphing, trends and predicting, tiling (math) -structure of atom (all science) -trends (history) -analyzing trends (family studies) -business cycles (Business) - ecozones (geography)
6	Group, taxonomy, sort, tabulate, arrange, class, analyze, analyze, hierarchy	Classification	-demographics, survey analysis (Contemp. Studies, Business), analyze, statistics (math/family studies) -taxonomy (biology), classifying heavenly bodies (astronomy), periodic table (chemistry) -genre (literature) -statistical analysis (geography) -market research data (BBI, BMI) -arrays combine (tech) -rock types, multicultural vegetation, weather forecasting (geography)

Figure 3: Overview of Curriculum Analyses

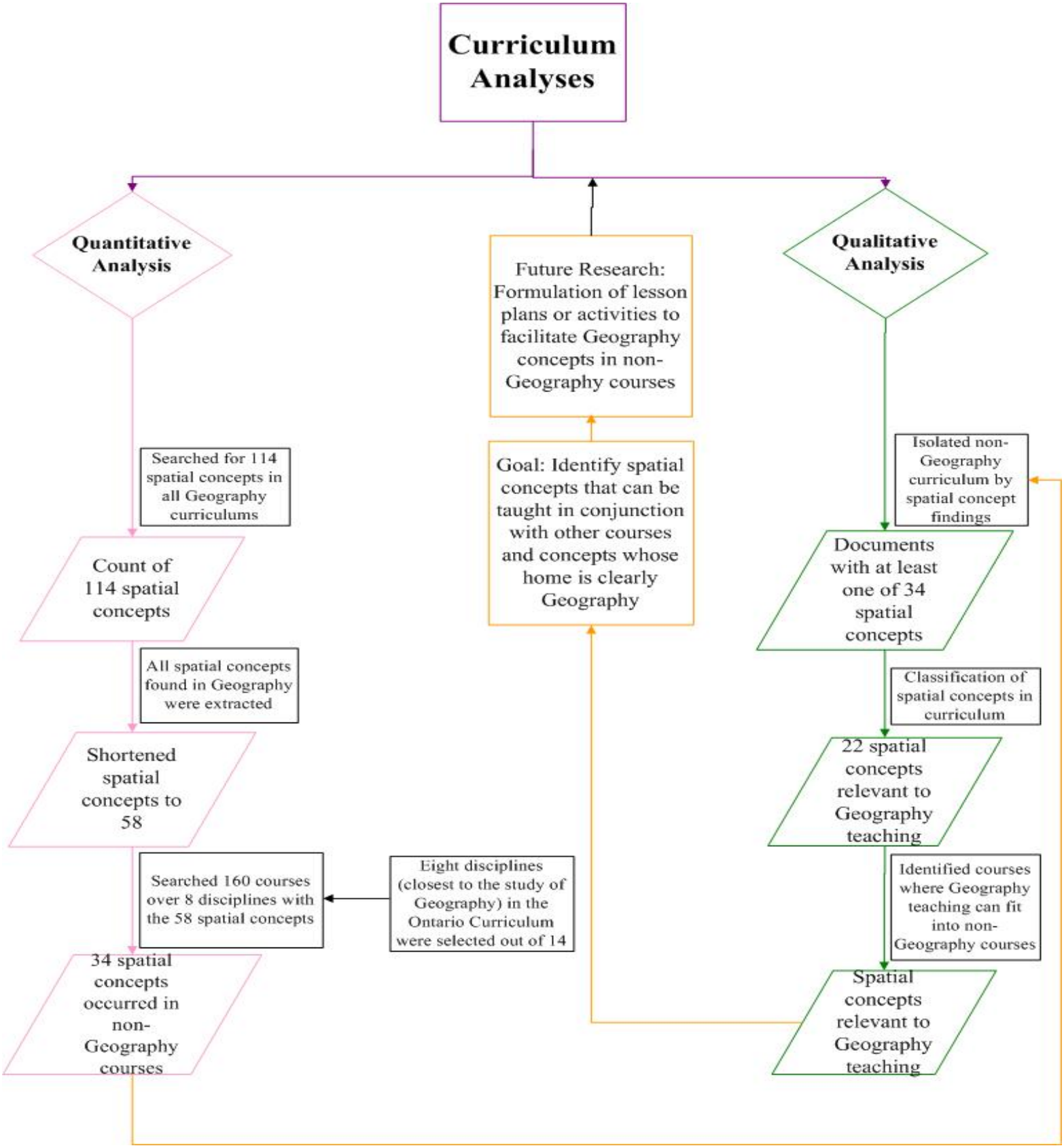

Figure 4: Geospatial Concepts on Search List

58 Concepts	34 Concepts	22 Concepts
analogue data		
Area	area	area
Aspect	aspect	
bearing	bearing	
buffer	buffer	
buffering	buffering	
cartography		
choropleth		
Circle	circle	
Classify	classify	classify
Contour	contour	
coordinates	coordinates	coordinates
datum		
demographics	demographics	demographics
digital data		
direction	direction	direction
distance	distance	
distance decay		
distribution	distribution	distribution
elevation	elevation	elevation
ellipsoid		
forms of settlement		
geographic data		
geographic information system (GIS)		
geography	geography	geography
geomatics		
GPS	GPS	GPS
latitude		
layering		
legend	legend	
locate	locate	
location	location	Location
longitude		
Map (s)	map	Map
Map projection		
movement	movement	movement
navigation	navigation	navigation
overlay		
place	place	place
position	position	position
projection	projection	projection
raster		

region	region	region
remote sensing	remote sensing	remote sensing
resolution	resolution	
scale	scale	scale
space	space	
spatial	spatial	spatial
spatial data		
spatial distribution		
spatial organization		
sphere	sphere	
symbol	symbol	symbol
thematic		
urban forms		
urban hierarchy		
vector	vector	vector
vector data models		

Figure 5: Frequency Counts of Geospatial Concepts:

Ontario Geography Curricula and Standards

Matrix Nodes	Geography Standards	Elementary Geography (1-8)	Geog 9	Geog 11	Geog 12	Total
Map	76	8	5	14	21	**124**
pattern	0	3	11	23	30	**67**
Region	23	4	5	14	15	**61**
Place	18	2	10	7	19	**56**
location	18	9	9	6	8	**50**
distribution	17	4	6	9	12	**48**
Data	8	6	7	16	10	**47**
spatial	21	0	2	5	15	**43**
geography	3	0	10	15	11	**39**
Time	17	7	3	4	5	**36**
Locate	8	20	2	2	1	**33**
Area	13	5	0	6	5	**29**
Forms	3	3	8	8	4	**26**
Group	2	0	3	5	14	**24**
Model	13	4	3	0	2	**22**
classify	3	10	0	2	5	**20**
Scale	3	2	2	4	8	**19**
remote sensing	0	0	0	8	10	**18**
thematic	3	5	2	3	5	**18**
with respect to	0	9	0	1	5	**15**
visual	1	1	2	4	7	**15**
Term	2	0	0	6	6	**14**
GIS	1	0	2	4	6	**13**
distance	5	2	0	1	5	**13**
Internet	1	0	3	5	3	**12**
class	4	5	0	1	2	**12**
Geomatics	0	7	0	0	4	**11**
Position	2	0	0	2	7	**11**
Shape	3	0	1	2	5	**11**
Direction	4	2	2	0	3	**11**
movement	6	1	0	2	2	**11**
GPS	1	0	0	3	5	**9**
Range	1	1	0	6	1	**9**
Relief	1	0	0	3	5	**9**
legend	1	2	2	1	2	**8**
measure	1	2	0	2	3	**8**
Navigation	2	0	0	4	2	**8**
Latitude	3	0	0	5	0	**8**
spatial distribution	4	0	0	0	4	**8**

space	5	1	0	1	1	**8**
focus	0	3	1	1	2	**7**
geographic data	0	0	5	0	2	**7**
Sort	0	7	0	0	0	**7**
design	1	3	1	2	0	**7**
forms of	1	2	4	0	0	**7**
statistics	1	4	0	1	0	**6**
spatial organization	2	0	2	0	2	**6**
accuracy	2	0	0	2	1	**5**
projection	2	0	0	0	3	**5**
cartography	0	0	0	2	2	**4**
Contour	0	2	0	1	1	**4**
elevation	0	1	0	1	2	**4**
longitude	1	1	0	2	0	**4**
Period	1	1	0	0	2	**4**
representation	1	0	1	1	1	**4**
Symbol	1	1	0	1	1	**4**
demographics	0	0	2	1	0	**3**
Overlay	0	0	0	1	2	**3**
properties	0	0	0	1	2	**3**
resolution	0	1	0	0	2	**3**
choropleth	1	0	0	1	1	**3**
characteristic	2	0	0	0	1	**3**
urban forms	2	0	0	0	1	**3**
Aspect	0	0	0	1	1	**2**
Attribute	0	1	0	1	0	**2**
buffering	0	0	0	1	1	**2**
Circle	0	0	0	0	2	**2**
continuous	0	0	0	1	1	**2**
coordinates	0	0	0	1	1	**2**
distance decay	0	0	0	0	2	**2**
forms of settlement	0	0	2	0	0	**2**
Input	0	0	0	0	2	**2**
Map projection	0	0	0	0	2	**2**
Output	0	1	0	0	1	**2**
Path	0	0	1	1	0	**2**
precision	0	0	0	1	1	**2**
sea level	0	0	0	0	2	**2**
spatial data	0	0	0	1	1	**2**
Sphere	0	1	0	0	1	**2**
frequency	1	0	0	1	0	**2**
Length	2	0	0	0	0	**2**
Altitude	0	1	0	0	0	**1**
analogue data	0	0	0	0	1	**1**
Bearing	0	0	0	0	1	**1**
Buffer	0	0	0	0	1	**1**
calculate	0	0	1	0	0	**1**
Datum	0	0	0	0	1	**1**
digital data	0	0	0	0	1	**1**
ellipsoid	0	0	0	0	1	**1**
hierarchy	0	0	0	0	1	**1**

Layering	0	0	0	0	1	**1**
Linear	0	1	0	0	0	**1**
Node	0	0	0	0	1	**1**
proportion	0	0	0	0	1	**1**
Rank	0	0	0	0	1	**1**
Raster	0	0	0	0	1	**1**
Track	0	0	0	1	0	**1**
urban hierarchy	0	0	0	0	1	**1**
Vector	0	0	0	0	1	**1**
vector data models	0	0	0	0	1	**1**
axis	1	0	0	0	0	**1**
add	0	0	0	0	0	**0**
angle	0	0	0	0	0	**0**
arrangement	0	0	0	0	0	**0**
decomposing	0	0	0	0	0	**0**
degree	0	0	0	0	0	**0**
discrete	0	0	0	0	0	**0**
dispersion	0	0	0	0	0	**0**
height	0	0	0	0	0	**0**
orientation	0	0	0	0	0	**0**
ratio	0	0	0	0	0	**0**
rule	0	0	0	0	0	**0**
unit	0	0	0	0	0	**0**
visualization	0	0	0	0	0	**0**
Total	**319**	**156**	**120**	**232**	**339**	**1166**

Figure 6: Frequency Counts of Geospatial Concepts:

Non-geography Curricula with Frequent Occurrences

Matrix Nodes	Business	Family	History	Math	Science	Technology	Total
Position (s)	8	3	21	7	47	21	107
Area (s)	5	6	0	12	39	16	78
space	1	6	3	4	25	1	40
distribution	16	5	3	5	4	2	35
movement	2	0	10	0	17	3	32
scale	3	2	0	6	13	7	31
place (s)	2	6	7	0	11	3	29
locate	3	4	4	2	13	0	26
location	3	2	5	2	11	3	26
classify	7	3	0	2	9	1	22
distance	1	1	0	10	7	2	21
vector	0	0	0	6	13	0	19
Map (s)	1	0	11	1	6	0	19
direction	0	0	0	4	9	4	17
Region (s)	6	0	0	4	4	3	17
demographics	4	0	5	0	1	1	11
resolution	0	6	1	0	1	3	11
projection	4	2	0	1	1	1	9
elevation	0	0	0	0	0	8	8
navigation	0	0	2	2	1	0	5
bearing	0	1	0	0	0	3	4
geography	1	1	2	0	0	0	4
legend	0	0	4	0	0	0	4
circle	0	0	0	3	0	0	3
symbol	0	2	0	1	0	0	3
aspect	0	1	0	0	1	0	2
buffer	0	0	0	0	2	0	2
buffering	0	0	0	0	2	0	2
contour	0	0	0	0	0	2	2
coordinates	0	0	0	2	0	0	2
spatial	0	1	0	0	0	1	2
gps	0	0	0	0	1	0	1
remote sensing	0	0	0	0	1	0	1
sphere	0	0	0	1	0	0	1
analogue data	0	0	0	0	0	0	0
cartography	0	0	0	0	0	0	0
choropleth	0	0	0	0	0	0	0
datum	0	0	0	0	0	0	0
digital data	0	0	0	0	0	0	0

distance decay	0	0	0	0	0	0	0
ellipsoid	0	0	0	0	0	0	0
forms of settlement	0	0	0	0	0	0	0
geographic data	0	0	0	0	0	0	0
geomatics	0	0	0	0	0	0	0
gis	0	0	0	0	0	0	0
latitude	0	0	0	0	0	0	0
layering	0	0	0	0	0	0	0
longitude	0	0	0	0	0	0	0
map projection	0	0	0	0	0	0	0
overlay	0	0	0	0	0	0	0
raster	0	0	0	0	0	0	0
spatial data	0	0	0	0	0	0	0
spatial distribution	0	0	0	0	0	0	0
spatial organization	0	0	0	0	0	0	0
thematic	0	0	0	0	0	0	0
urban forms	0	0	0	0	0	0	0
urban hierarchy	0	0	0	0	0	0	0
vector data models	0	0	0	0	0	0	0
Total	**67**	**52**	**78**	**75**	**239**	**82**	**596**

Figure 7: Frequency Counts of Geospatial Concepts:

Non-geography Curricula with Infrequent Occurrences

Matrix Nodes	Economics	Social Science	Law	Native	Philo	PhysEd	Poli Sci	Religion	Total
movement	0	0	0	0	0	15	0	0	15
resolution	0	0	4	0	0	5	2	0	11
classify	3	0	2	1	1	0	2	0	9
Area(s)	0	2	5	6	2	1	0	1	17
place	0	0	0	4	0	1	0	2	7
Position (s)	0	1	0	2	2	0	2	0	7
distribution	2	1	0	0	1	0	0	0	4
Map (s)	0	0	1	1	0	0	2	0	4
distance	0	1	0	1	0	1	0	0	3
direction	0	0	0	1	0	0	0	1	2
locate	1	1	0	0	0	0	0	0	2
location	0	0	0	1	0	1	0	0	2
scale	0	0	1	1	0	0	0	0	2
space	0	0	0	0	1	0	1	0	2
aspect	0	0	0	1	0	0	0	0	1
geography	0	0	0	0	0	0	1	0	1
region	0	0	0	1	0	0	0	0	1
symbol	0	0	0	0	0	0	0	1	1
analogue data	0	0	0	0	0	0	0	0	0
bearing	0	0	0	0	0	0	0	0	0
buffer	0	0	0	0	0	0	0	0	0
buffering	0	0	0	0	0	0	0	0	0
cartography	0	0	0	0	0	0	0	0	0
choropleth	0	0	0	0	0	0	0	0	0
circle	0	0	0	0	0	0	0	0	0
contour	0	0	0	0	0	0	0	0	0
coordinates	0	0	0	0	0	0	0	0	0
datum	0	0	0	0	0	0	0	0	0
demographics	0	0	0	0	0	0	0	0	0
digital data	0	0	0	0	0	0	0	0	0
distance decay	0	0	0	0	0	0	0	0	0
elevation	0	0	0	0	0	0	0	0	0
ellipsoid	0	0	0	0	0	0	0	0	0
forms of settlement	0	0	0	0	0	0	0	0	0
geographic data	0	0	0	0	0	0	0	0	0
geomatics	0	0	0	0	0	0	0	0	0
gis	0	0	0	0	0	0	0	0	0
gps	0	0	0	0	0	0	0	0	0
latitude	0	0	0	0	0	0	0	0	0
layering	0	0	0	0	0	0	0	0	0
legend	0	0	0	0	0	0	0	0	0

longitude	0	0	0	0	0	0	0	0	0
map projection	0	0	0	0	0	0	0	0	0
navigation	0	0	0	0	0	0	0	0	0
overlay	0	0	0	0	0	0	0	0	0
projection	0	0	0	0	0	0	0	0	0
raster	0	0	0	0	0	0	0	0	0
remote sensing	0	0	0	0	0	0	0	0	0
spatial	0	0	0	0	0	0	0	0	0
spatial data	0	0	0	0	0	0	0	0	0
spatial distribution	0	0	0	0	0	0	0	0	0
spatial organization	0	0	0	0	0	0	0	0	0
sphere	0	0	0	0	0	0	0	0	0
thematic	0	0	0	0	0	0	0	0	0
urban forms	0	0	0	0	0	0	0	0	0
urban hierarchy	0	0	0	0	0	0	0	0	0
vector	0	0	0	0	0	0	0	0	0
vector data models	0	0	0	0	0	0	0	0	0
Total	6	6	13	20	7	24	10	5	91

Figure 8: Selected Courses with Geospatial Content

Subject	Course Code	Name of document	Geospatial concepts
Business Studies	BBB4M	Introduction to International Business, Grade 12, University/College Preparation	global distribution, local, national, and international distribution, movement
Business Studies	BMX3E	Introduction to Retail and Services Marketing, Grade 11, Workplace Preparation	demographics, location
Canadian and World Studies	CHM4E	Adventures in World History, Grade 12, Workplace Preparation	geography, location, map, navigation
Canadian and World Studies	CHW3M	World History to the Sixteenth Century, Grade 11, University/College Preparation	geography, map, position
Social Sciences and the Humanities	HFA4M	Food and Nutrition Sciences, Grade 12, University/College Preparation	distribution of wealth, geographical location
Mathematics	MEL4E	Mathematics for Everyday Life, Grade 12, Workplace Preparation	area, distance, map, region, scale drawing/model
Mathematics	MGA4U	Geometry and Discrete Mathematics, Grade 12, University Preparation	coordinate system, projection, vector
Native Studies	NDW4M	Issues of Indigenous Peoples in a Global Context, Grade 12, University/College Preparation	geographical area, location. map, place
Science	SES4U	Earth and Space Science, Grade 12, University Preparation	local area, geological history of an area, classify, direction, distance, location, map, movement, place, position, remote sensing, time scale,
Science	SNC2D	Science, Grade 10, Academic	area, direction, distance, geographical location, movement
Science	SNC4M	Science, Grade 12, University/College Preparation	demographics, distribution of natural resources, GPS, scale, symbolic
Technological Education	TTJ3C	Transportation Technology, Grade 11, College Preparation	demographics, distance, movement, region, Scale drawing/model

The following pages provide the full excerpts of the learning expectations that relate to geospatial knowledge for each of the courses listed above.

Business Studies BBB4M Introduction to International Business, Grade 12, University/College Preparation

Geospatial concepts: global distribution, local, national, and international distribution, movement

Paragraph 39
By the end of this course, students will: describe the modifications made to goods and services to adapt them to the cultures of other countries; describe the challenges a company may encounter when ethics, values, language, and business practices vary among countries and cultures; analyse how differences among cultures affect consumer needs and wants; explain how the global market (e.g., global distribution and availability of products) has homogenized consumer demand.

Paragraph 41
By the end of this course, students will: demonstrate an understanding of the challenges facing a business that wants to market a product internationally; compare the approaches taken by various companies to market their products internationally; compare the logistics of local, national, and international distribution; analyse the ways in which ethical issues affect international distribution and service.

Paragraph 44
By the end of this course, students will: compare categories of products that move freely into and out of Canada with those that are restricted in their movement; compare the challenges a company faces in getting a product to different markets; determine the importance of understanding consumer differences when marketing globally (e.g., differences in cultural, economic, and other characteristics); describe the ways in which technology (e.g., e-commerce, advances in distribution and manufacturing, electronic communication) is influencing global marketing strategies.

Business Studies BMX3E Introduction to Retail and Services Marketing, Grade 11, Workplace Preparation

Geospatial concepts: demographics, location

Paragraph 11
By the end of this course, students will: relate changing demographics and lifestyles in Canada to changes in the tastes, preferences, and priorities of Canadian consumers; relate changes in consumer needs and wants over the past few decades to changes in retail and service businesses (e.g., consumer demand for fast food, portable communication devices); identify the types of consumer groups that use specific retail and service businesses within their community; describe how information technology has had an impact on businesses' ability to identify and respond to customer needs; explain the importance of marketing research; explain the process by which consumers make a buying decision.

Paragraph 23
By the end of this course, students will: differentiate among the various channels of distribution; explain changes in the distribution of goods and services due to changes in customer shopping preferences (e.g., mega malls, big-box retailing); explain changes in the distribution of products due

to changes in information technology (e.g., the virtual mall, the Internet); analyse the factors contributing to the selection of virtual or real locations by retail and service businesses; describe the variations in marketing techniques used to place products (e.g., consumer products, wholesale products) in different markets.

Canadian and World Studies CHM4E Adventures in World History, Grade 12, Workplace Preparation

Geospatial concepts: geography, location, map, navigation

Paragraph 11
By the end of this course, students will: identify key developments in communications technologies from the Stone Age to the present (e.g., written language and alphabets, paper making and the printing press, wire and wireless transmission, satellite telecommunications) and evaluate their effects on interactions between communities; identify key developments in transportation technologies from the Stone Age to the present (e.g., use of animals, development of astrological navigation systems, development of sail and steam technologies, invention of the internal combustion engine, aerospace innovations) and evaluate their effects on interactions between communities; identify key developments in scientific and medical technologies from the Stone Age to the present (e.g., development of different calendar systems, changing perceptions of geography and astronomy, developments in modern medicine) and describe their impact on the community.

Paragraph 41
By the end of this course, students will: describe the development of currencies and credit systems, from early barter to the modern Western consumer economy (e.g., wampum, weights and measures, minted coins, paper money, Renaissance banking and double-entry bookkeeping, stock markets, personal credit, electronic banking); identify the location and purposes of different trade routes (e.g., the Silk Road; the Atlantic triangle; the Yangtze, Mekong, Nile, Indus, Mississippi, and St. Lawrence Rivers; routes along canal and railway systems); identify pivotal examples of the human drive to explore new frontiers, and describe some of the economic effects of these ventures (e.g., Marco Polo and the reawakening of overland Asian trade routes; conquistadors, Incan gold, and the sixteenth-century "price revolution"; aerospace programs and their influence on the telecommunications industry).

Paragraph 49
By the end of this course, students will: formulate a variety of questions to serve as a basis for research, drawing on examples from world history (e.g., What were some of the technological developments in Neolithic farming? What were some of the motives for building the Great Wall of China or the Mayan pyramids? What are the characteristics of a "civilization"?); conduct organized research, using a selection of information sources (e.g., textbooks and reference books, newspapers and magazines, audio-visual materials, Internet sites); organize research findings, using a variety of methods and forms (e.g., note taking; graphs and charts, maps and diagrams).

Canadian and World Studies CHW3M World History to the Sixteenth Century, Grade 11, University/College Preparation

Geospatial concepts: geography, map, position

Paragraph 9
By the end of this course, students will: describe the characteristics that are common to stable societies (e.g., accepted leadership; tradition and law; compatible religious beliefs); identify the factors that tend to differentiate societies (e.g., external pressures, decisions of leaders, geography); identify the forces that led different peoples to choose their particular forms of social organization (e.g., Indian caste societies, Spartan military systems, Japanese feudal society).

Paragraph 49
By the end of this course, students will: formulate significant questions for research and inquiry, drawing on examples from world history to the sixteenth century (e.g., What was the role of religion in the lives of the Aztec people? To what extent did the barbarian invaders contribute to the collapse of the Roman Empire? What were the effects of the Black Death on medieval European society?); conduct organized research, using a variety of information sources (e.g., primary and secondary sources, audio-visual materials, Internet sites); organize research findings, using a variety of methods and forms (e.g., note taking; graphs and charts, maps and diagrams).

Paragraph 11
By the end of this course, students will: explain the development of societies from simpler to more complex forms (e.g., from hunter-gatherer to rural agricultural to urban industrial societies); identify, through analysis, the reasons for the predominance of particular societies (e.g., their position on trade routes, Roman concepts of government, Muhammad's religious evangelism); evaluate the criteria that a society must meet to be regarded as a "civilization" (e.g., longevity, lasting influence of cultural contribution, significance of role in events of the period).

Social Sciences and the Humanities HFA4M Food and Nutrition Sciences, Grade 12, University/College Preparation

Geospatial concepts: distribution of wealth, geographical location

Paragraph 54
investigate the extent of hunger in the world today and present the results of their investigation; describe micro-nutrient deficiencies (e.g., iron, iodine, vitamin A) prevalent in Canada and throughout the world; summarize the causes of food insecurity (e.g., an emphasis on cash-cropping and large-scale food production, globalization, urbanization, continued feminization of poverty); identify economic and social policies that influence food security (e.g., debt restructuring, the operations of the World Bank); describe the social and cultural traditions that account for inequality among peoples of the world (e.g., gender issues, distribution of wealth, failure to support small business); identify the ways in which the local community is responding to hunger and food security (e.g., with food banks, community gardens); describe policies necessary to protect the health and safety of food producers (e.g., against the risk of contaminants), and to protect land and water quality, and biodiversity.

Paragraph 11

identify psychological and emotional factors that affect eating habits (e.g., eating to relieve tension or boredom, deriving comfort from food); describe the socio-cultural importance of food in social interactions (e.g., celebrations and gatherings of friends; family rituals; in the transmission of family culture, religion, and traditions; as a symbol of hospitality; as a status symbol); describe economic factors that have an impact on the food choices of individuals and families; identify the ways in which physical factors influence food choices (e.g., geographical location, regional growing seasons, availability of food markets, home storage capacity); plan menus for, select, and prepare foods, taking into consideration economic, geographical, and seasonal factors that affect the availability of ingredients.

Mathematics MEL4E Mathematics for Everyday Life, Grade 12, Workplace Preparation

Geospatial concepts: area, distance, map, region, scale drawing/model

Paragraph 33

By the end of this course, students will: demonstrate an understanding of the Pythagorean theorem, by constructing on a floor a rectangular region having accurate right-angled corners; determine the perimeter and area of regular and irregular figures from given diagrams; estimate, with reasonable accuracy, perimeters and areas of large regions (e.g., a playing field), and explain the strategies used; demonstrate an understanding of the effect on the area of familiar objects (e.g., a photograph, a television screen, a road map) of multiplying each dimension by the same factor; make a two-dimensional scale drawing of a room, using design or drawing software effectively; create a three-dimensional drawing of the interior of a room, using design or drawing software effectively; construct, with reasonable accuracy, a scale model of an environment of personal interest (e.g., a building, a garden, a bridge); estimate and calculate the surface area and volume of objects and containers in the surrounding environment that approximate the shape of rectangular prisms and cylinders; investigate the making of a household improvement (e.g., landscaping a property, decorating a room), design the improvement, and estimate and calculate the cost, using technology (e.g., spreadsheets, design or drawing software).

Paragraph 31

By the end of this course, students will: demonstrate a working knowledge of the metric system; measure lengths accurately, using the metric system and the imperial system; estimate distances in metric units and in imperial units by applying personal referents (e.g., the width of a finger is approximately 1 cm; the length of a piece of standard loose-leaf paper is about 1 foot); estimate capacities in metric units by applying personal referents (e.g., a can of pop is about 350 mL); estimate, with reasonable accuracy, large numbers that are illustrated visually (e.g., books on a wall in a library, pictures of crowds, populations of high-rise buildings), and explain the strategies used.

Mathematics MGA4U Geometry and Discrete Mathematics, Grade 12, University Preparation

Geospatial concepts: coordinate system, projection, vector

Paragraph 19
By the end of this course, students will: solve problems by effectively combining a variety of problem-solving strategies (e.g., brainstorming, considering cases, choosing algebraic/geometric/vector or direct/indirect approaches, working backwards, visualizing by using concrete materials or diagrams or software, iterating, varying parameters, creating a model, introducing a coordinate system); generate multiple solutions to the same problem; use technology effectively in making and testing conjectures; solve complex problems and present the solutions with clarity and justification.

Paragraph 9
By the end of this course, students will: represent vectors as directed line segments; perform the operations of addition, subtraction, and scalar multiplication on geometric vectors; determine the components of a geometric vector and the projection of a geometric vector; model and solve problems involving velocity and force; determine and interpret the dot product and cross product of geometric vectors; represent Cartesian vectors in two-space and in three-space as ordered pairs or ordered triples; perform the operations of addition, subtraction, scalar multiplication, dot product, and cross product on Cartesian vectors.

Paragraph 2
This course enables students to broaden mathematical knowledge and skills related to abstract mathematical topics and to the solving of complex problems. Students will solve problems involving geometric and Cartesian vectors, and intersections of lines and planes in three-space. They will also develop an understanding of proof, using deductive, algebraic, vector, and indirect methods. Students will solve problems involving counting techniques and prove results using mathematical induction.

Native Studies NDW4M Issues of Indigenous Peoples in a Global Context, Grade 12, University/College Preparation

Geospatial concepts: geographical area, location, world map, place

Paragraph 33
Describe a forum (e.g., the Inuit Circumpolar Conference, the International Alliance of the Indigenous Tribal Peoples of the Tropical Forests) in which indigenous peoples work together to influence the policy makers of nation states that have a presence in a geographical area (e.g., countries that control parts of the Arctic); identify examples where indigenous peoples and different national governments have developed strategies to improve their relations with each other (e.g., Australia's Council for Aboriginal Reconciliation, Canada's Statement of Reconciliation with Aboriginal Peoples); demonstrate an understanding of how an indigenous group has used a philosophical attachment to its traditional lands (e.g., the Maori of New Zealand, the Aborigines of Australia) as a means of maintaining the group's cultural identity; identify principles that indigenous

peoples uphold by their participation in international bodies and organizations (e.g., the principles of sustainability, preservation of community, respect for fundamental human rights).

Paragraph 14
Demonstrate an understanding of the term indigenous peoples, which is used instead of Aboriginal in international contexts; identify the location of various indigenous populations on a world map (e.g., the Karen in Thailand, the Maori in New Zealand); describe how indigenous peoples throughout the world have responded to economic trends in the global economy and yet maintained their traditional way of life; demonstrate an understanding of how different indigenous peoples affirm their identity (e.g., through indigenous non-governmental organizations); assess national and international reactions to indigenous peoples' efforts to identify themselves as distinct peoples within the global community.

Paragraph 44
Explain a variety of views on indigenous sovereignty (e.g., as outlined in the Draft United Nations Declaration on the Rights of Indigenous Peoples or in International Labour Organizations Convention No. 169 on the Rights of Indigenous Peoples and Tribal Populations); identify examples in which indigenous peoples throughout the world have acted to protect their land, their culture, or their community's livelihood (e.g., the armed resistance of the Indians of Chiapas, Mexico; the Seminole people's resistance to American government efforts to relocate them, 1835; the Oka crisis in Canada, 1990); demonstrate an understanding of the place of indigenous nations within the global political system; identify, through analysis, some of the limitations preventing indigenous peoples in different parts of the world (e.g., the Maori of New Zealand, the Maasi of Tanzania, the Manabos of the Philippines) from exercising authority in their own affairs, and compare their responses;

Science SES4U Earth and Space Science, Grade 12, University Preparation

Geospatial concepts: local area, geological history of an area, classify, direction, distance, location, map, movement, place, position, remote sensing, time scale, symbolic

Paragraph 28
By the end of this course, students will: distinguish between minerals and rocks, and describe the formation and characteristics of both; apply a series of specific tests to identify minerals and rocks, including those in the local area, and to determine their physical properties; demonstrate an understanding of society's dependence on Earth materials, of the effects of developments in technology on the exploration and mining of Earth materials, and of the ways in which the use and extraction of Earth materials have affected natural and human-made environments.

Paragraph 33
By the end of this course, students will: apply a series of tests (e.g., tests evaluating hardness, streak, and density) to identify common minerals (e.g., quartz, calcite, potassium feldspar, plagioclase feldspar, muscovite, biotite, talc, graphite, gold, silver); identify and classify €selected hand samples of unknown minerals on the basis of their physical properties (e.g., sort the groups by hardness, colour, streak); apply a series of tests to identify common igneous rocks (e.g., granite, obsidian, andesite, basalt, gabbro, peridotite), and classify each according to its origin (e.g., volcanic, plutonic), texture (e.g., coarse- or fine-grained, vesicular, glassy), and composition (e.g., mafic,

felsic, intermediate); apply a series of tests to identify sedimentary rocks (e.g., conglomerate, breccia, sandstone, shale, limestone, chert, gypsum, rock salt, coal), and classify each according to its origin (e.g., clastic, chemical), texture (e.g., coarse- or fine-grained, detrital), and composition; apply a series of tests to identify and classify metamorphic rocks (e.g., slate, phyllite, schist, gneiss, quartzite, marble) and, on the basis of the characteristics of each type, identify its parent rock and the temperature, pressure, and chemical conditions at its formation; investigate and describe the geological setting of the local area (e.g., examine the geological setting of a local river/stream bed or lakeshore, and identify and classify rock types on the basis of representative samples collected at the site).

Paragraph 35
By the end of this course, students will: explain the importance of minerals and other Earth resources (e.g., sand, gravel, dimension stone, oil and gas), and of exploration for these resources, for the local, provincial, and national economies; describe and assess the role of Earth materials in the safe disposal of industrial and urban waste and toxic materials; describe the uses and evaluate the economic importance of minerals, rocks, and metallic resources (e.g., gold, silver, nickel, copper) and non-metallic resources (e.g., sand and gravel, aggregates, oil and gas, lime, gypsum, industrial minerals, gems); describe the use of dimension stone (e.g., in buildings and cemeteries) and explain how the development of new technologies has influenced the type of stone used in the local area (e.g., relate advances in the technology for quarrying and cutting stone to changes in the type of stone used); describe some of the technologies used to recover natural resources from the Earth, and evaluate economic, social, and environmental ramifications of their use (e.g., the need for fewer workers and the practice of site rehabilitation resulting from the use of improved technologies in the mining of nickel).

Paragraph 14
By the end of this course, students will: explain how the study of other planets and objects in the solar system has led to a better understanding of the Earth (e.g., explain how studying the greenhouse effect on Venus has increased understanding of the same effect on Earth); demonstrate an understanding of some of the historical, cultural, and aesthetic consequences of changes in the perception and understanding of the Earth's place in space (e.g., evaluate the impact of images of the whole Earth taken from space); describe how observations and measurements of the Earth made from space are used to study and better understand natural physical elements of the Earth's environment (e.g., its crust, water, air) as well as human-made elements (e.g., crops, cities, air and water pollution); describe the challenges of designing piloted and robotic spacecraft, and of operating them in near-Earth space; investigate Canada's contributions to the study of our planet from near-Earth space (e.g., Radarsat, International Space Station), using information from various print and electronic sources; evaluate the negative effects of human activity on near-Earth space (e.g., space debris, pollution of the electromagnetic spectrum).

Paragraph 4
Throughout this course, students will: demonstrate an understanding of Workplace Hazardous Materials Information System (WHMIS) legislation by selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., following safety procedures when sampling rocks; using materials safely when identifying minerals and rocks), and by using appropriate personal protection (e.g., wearing safety glasses when sampling, and hard hats when visiting outcrops and quarries); select appropriate instruments and use them safely, effectively, and accurately in collecting observations and data (e.g., hand lens, polarizing microscope); use safe

procedures to protect the eyes when observing the sky by day, and choose safe, secure locations when observing the sky at night; demonstrate an understanding of emergency laboratory procedures; select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate scientific ideas, plans, and experimental results (e.g., use an appropriate time scale when representing geological time, or appropriate units to represent astronomical distances); select, integrate, and analyse information from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including flow charts, tables, and graphs (e.g., use the Internet to compile information on areas of major earthquake activity, and compare the frequency and intensity of the activity in graphical form); communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports (e.g., prepare a table of known and unknown minerals sorted in groups according to physical properties such as hardness, colour, and streak); express the result of any calculation involving experimental data to the appropriate number of decimal places or significant figures; select and use appropriate SI units (units of measurement of the Système international d'unités, or International System of Units); identify and describe careers related to Earth and space science (e.g., careers related to hydrology, meteorology, geology, mineralogy, astronomy, and remote sensing).

Paragraph 44
By the end of this course, students will: describe, on the basis of information gathered from print and electronic sources, the various types of possible margins between lithospheric plates (e.g., convergent, divergent, transform, and intraplate activity) and the types of internal Earth processes occurring at each; produce diagrams of the following structures, and identify examples of them in maps and photographs: normal, reverse, thrust, and strike-slip (transform) faults; domes and basins; anticlines and synclines; investigate and produce a model of each type of seismic wave, using springs and ropes, and describe for each the nature of its propagation and the resulting movement within the rocks through which it is travelling; compare qualitative and quantitative methods (e.g., the Mercalli Scale and the Richter Scale) used to measure earthquake intensity and magnitude; produce a diagram or model, to scale, of the interior of the Earth in order to differentiate among the layers of the Earth and their characteristics (e.g., use cross-sections to provide the dimensions of crust, mantle, and inner and outer core, and travel-time curves for various seismic waves to provide data on the characteristics of the individual layers); design and construct a working model of a seismograph, and explain its use in recording earthquake activity; locate the epicentre of an earthquake, given the appropriate seismographic data (e.g., the travel-time curves to three recording stations for a single event); design and test methods to control mass wasting; relate the characteristics of sediment (e.g., grain size, shape, composition) to the velocity and direction of currents in a beach or stream environment (e.g., examine where sediment is being eroded and deposited in a local beach or river/stream environment); investigate and explain the interrelationship among geological maps, cross-sections, and block diagrams, and the ways in which they represent the subsurface structure and/or the geological history of an area.

Paragraph 46
By the end of this course, students will: describe methods of monitoring and predicting earthquakes, tsunamis, and volcanic eruptions; describe and explain how the development of the seismograph has contributed to a better understanding of the internal structure of the Earth; identify and describe engineering and technological innovations and adaptations resulting from human activity in areas of permafrost (e.g., pipeline construction, oil and natural gas exploration, residential construction and urbanization); identify and describe engineering and technological innovations and adaptations (e.g.,

in building design, highway construction, emergency services) resulting from the impact of earthquake activity on human populations; describe the underlying assumptions and the limitations of predictions of earthquake activity, and assess the implications of such predictions for populations in Canada and around the world; identify major areas of tectonic activity in the world (e.g., Japan - convergent margin; Iceland - divergent margin; California - transform fault), drawing on information about the relationship between earthquakes, volcanoes, and plate boundaries (e.g., plot on a world map, for a given time period, the locations of recorded earthquakes and active volcanoes); demonstrate an understanding of how erosion and deposition by streams are affected by load, gradient, channel shape, sediment composition, and human activities.

Paragraph 24
By the end of this course, students will: explain the interactions of the atmosphere and hydrosphere in the water cycle, and the impact of these interactions on humans; describe and explain the effects of natural systems on the Earth's physical and human environments, and the increasing alteration of certain natural systems that has resulted from human activities; analyse, through cooperative research, national and international Earth science endeavours (e.g., Lithoprobe, Ocean Drilling Program) that have increased our understanding of the Earth's crust, and assess the merits of funding such projects; assess how developments in technology have contributed to our understanding of the Earth (e.g., the development of sonar to map the ocean floor).

Paragraph 54
By the end of this course, students will: use and interpret information from appropriate sources (e.g., a sequence diagram, geological maps showing major geological regions and associated rock types) in describing the geological history of an area (e.g., Ontario); investigate and analyse various types of preserved geological evidence of changes that have taken place in Earth history (e.g., past glaciations, tectonic activity, plate movement); demonstrate an understanding of the evolution of life, as revealed through fossil analysis; demonstrate the ability to use the geological time scale as an aid in interpreting the history of a sequence of strata; investigate and interpret the significance of an unconformity preserved in a sequence of strata (e.g., the boundary between Paleozoic and Precambrian rocks in southern Ontario); investigate radioactive decay and the concept of half-life determination (e.g., design a simple, safe experiment that provides a model of half-life decay of radioactive elements); analyse the evidence used to determine the age of the Earth (e.g., radiometric dating of geological materials), and outline the historical evolution of attempts to establish the Earth's chronology.

Science SNC2D Science, Grade 10, Academic

Geospatial concepts: area, direction, distance, geographical location, movement, symbolic

Paragraph 12
By the end of this course, students will: assess the impact of technological change and natural change on an ecosystem (e.g., the introduction of fertilizer and pesticides to soil; the introduction of a genetically engineered plant or the effect of polluted water or air on plants and animals; the effect on an ecosystem of forest fire, flood, the natural infection of one species, or the movement of a species in or out of the area); describe ways in which the relationships between living organisms and their ecosystems are viewed by other cultures (e.g., First Nations); identify and research a local issue involving an ecosystem; propose a course of action, taking into account human and environmental needs; and defend their position in oral or written form (e.g., organize and participate in a debate on

converting a grass lot into a parking lot); describe the physical and chemical processes involved in the methods used to clean up a contaminated site (e.g., how absorbent chemicals such as charcoal work in cleaning up oil spills); identify and evaluate Canadian initiatives in protecting Canada's ecosystems; explain changes in popular views about the sustainability of ecosystems and humans' responsibility in preserving them (e.g., the shift from a belief that all resources are inexhaustible to the belief that recycling, reusing, and reducing are important); describe careers that involve knowledge of ecology or environmental technologies, and use resources such as the Internet to determine the knowledge and skill requirements of such careers.

Paragraph 62
By the end of this course, students will: describe the historical development of a technology (e.g., crop fertilization), and analyse why and how it was developed and improved over time; compare various points of view on an environmental issue (e.g., a proposal to dump garbage in a quarry that is adjacent to a residential area; the sustainability of current agricultural practices); explain the benefits of individual and societal participation in planning, problem solving, decision making, and task completion with respect to environmental issues (e.g., summarize the results of a group project on sustainable agriculture; establish an ecosystem, modify it, and review the results); analyse the risks and benefits to society, the economy, and the environment of introducing a particular technology (e.g., nuclear power; genetically engineered micro-organisms for pollution clean-up; algae ponds to process sewage).

Paragraph 28
By the end of this course, students will: identify and describe the principal characteristics of the hydrosphere and the four regions of the atmosphere; describe and explain heat transfer within the water cycle and how the hydrosphere and atmosphere act as heat sinks; describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water currents; describe and explain the effects of heat transfer within the hydrosphere and atmosphere on the development, severity, and movement of weather systems (e.g., effects such as pressure gradients, cloud formation, winds); explain different types of transformations of water vapour in the atmosphere and their effects (e.g., clouds, hail, freezing rain, ice pellets, fog, frost, rain, snow); describe the factors contributing to earth temperature gradients and to wind speed and direction; describe cyclones, hurricanes, tornadoes, and monsoons in terms of the meeting of air masses, atmospheric humidity, and the jet stream.

Paragraph 38
By the end of this course, students will: distinguish among and provide examples of scalar and vector quantities as they relate to the description of linear motion (e.g., among distance d, displacement , and position , and between speed v and velocity); add collinear displacement vectors algebraically and graphically and non-collinear displacement vectors graphically; distinguish among constant, instantaneous, and average speed and among constant, instantaneous, and average velocity, and give examples involving uniform and non-uniform motion; describe quantitatively the relationship among one-dimensional average speed, distance travelled d, and elapsed time t, and solve simple problems involving these physical quantities

Paragraph 42
By the end of this course, students will: through investigations and applications of basic concepts: formulate scientific questions about observed relationships, ideas, problems, and issues related to motion (e.g., "What are the different acceleration characteristics of different transportation

vehicles?"); demonstrate the skills required to plan and conduct an inquiry into motion, controlling major variables and adapting or extending procedures where required (e.g., determine the time or distance intervals at which measurements should be taken to calculate the average velocity of a bicycle rider); use a broad range of tools and techniques safely, accurately, and effectively to compile, record, and analyse data and information, and apply mathematical and conceptual models to develop and assess possible explanations (e.g., stopwatches, photo-gates, length-measurement devices, and motion sensors to obtain data; electronic spreadsheets and graphs to record and analyse the data); select and integrate information from various sources, including electronic and print resources, to answer the questions chosen; analyse data and information and evaluate evidence and sources of information, identifying flaws such as errors and bias (e.g., determine the mathematical relationship among displacement, velocity, and time, and identify any sources of error in data collection); identify, explain, and express sources of error and uncertainty in experimental measurements; select and use appropriate vocabulary, SI units, and numeric, symbolic, graphic, and linguistic modes of representation to communicate scientific ideas, plans, results, and conclusions (e.g., present a graph showing an object's velocity, ensuring that the variables are on the appropriate axis); design, conduct, and evaluate experiments to measure the displacement, velocity, and acceleration of a moving object in one dimension, for both uniform motion and constant acceleration; design, conduct, and evaluate an experiment to measure acceleration due to gravity; use simple graphs and vector diagrams to describe predicted and observed motion in one dimension.

Paragraph 8
By the end of this course, students will: describe the processes of photosynthesis and cellular respiration as they relate to the cycling of energy, carbon, and oxygen through abiotic and biotic components of an ecosystem (e.g., explain that photosynthesis and cellular respiration are essentially reverse processes, and identify the reactants and products of their overall reactions); illustrate the cycling of matter through biotic and abiotic components of an ecosystem by tracking nitrogen; explain the process of bioaccumulation and assess its potential impact on the viability and diversity of consumers at all trophic levels; examine the factors (natural and external) that affect the survival and equilibrium of populations in an ecosystem (e.g., resource limits of an ecosystem, competing populations, bioaccumulation, selective decline); examine how abiotic factors affect the survival and geographical location of biotic communities (e.g., explain why deserts exist in different parts of the world); explain why different ecosystems respond differently to short-term stresses and long-term changes (e.g., short term: the activity of tent caterpillars during a season; long-term: the effect of acid rain on maple trees); compare a natural and a disturbed ecosystem and suggest ways of assuring their sustainability (e.g., compare a meadow and a lawn); explain how soil composition and fertility can be altered in an ecosystem and identify the possible consequences of such changes.

Paragraph 12
By the end of this course, students will: assess the impact of technological change and natural change on an ecosystem (e.g., the introduction of fertilizer and pesticides to soil; the introduction of a genetically engineered plant or the effect of polluted water or air on plants and animals; the effect on an ecosystem of forest fire, flood, the natural infection of one species, or the movement of a species in or out of the area); describe ways in which the relationships between living organisms and their ecosystems are viewed by other cultures (e.g., First Nations); identify and research a local issue involving an ecosystem; propose a course of action, taking into account human and environmental needs; and defend their position in oral or written form (e.g., organize and participate in a debate on converting a grass lot into a parking lot); describe the physical and chemical processes involved in the methods used to clean up a contaminated site (e.g., how absorbent chemicals such as charcoal

work in cleaning up oil spills); identify and evaluate Canadian initiatives in protecting Canada's ecosystems; explain changes in popular views about the sustainability of ecosystems and humans' responsibility in preserving them (e.g., the shift from a belief that all resources are inexhaustible to the belief that recycling, reusing, and reducing are important); describe careers that involve knowledge of ecology or environmental technologies, and use resources such as the Internet to determine the knowledge and skill requirements of such careers.

Paragraph 28
By the end of this course, students will: identify and describe the principal characteristics of the hydrosphere and the four regions of the atmosphere; describe and explain heat transfer within the water cycle and how the hydrosphere and atmosphere act as heat sinks; describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water currents; describe and explain the effects of heat transfer within the hydrosphere and atmosphere on the development, severity, and movement of weather systems (e.g., effects such as pressure gradients, cloud formation, winds); explain different types of transformations of water vapour in the atmosphere and their effects (e.g., clouds, hail, freezing rain, ice pellets, fog, frost, rain, snow); describe the factors contributing to earth temperature gradients and to wind speed and direction; describe cyclones, hurricanes, tornadoes, and monsoons in terms of the meeting of air masses, atmospheric humidity, and the jet stream.

Paragraph 30
By the end of this course, students will: through investigations and applications of basic concepts: formulate scientific questions about weather-related phenomena, problems, and issues (e.g., "What is the effect of heat energy transfer within the hydrosphere?"); demonstrate the skills required to plan and conduct a weather-related inquiry, using a broad range of tools and techniques safely and accurately, and adapting or extending procedures where required (e.g., determine how the accuracy of weather predictions can be maintained when data from several places and people are combined); select and integrate information from various sources, including electronic and print resources, to answer the questions chosen; analyse data and information and evaluate evidence and sources of information, identifying flaws such as errors and bias (e.g., explain possible sources of error when interpreting a satellite picture used for predicting weather); select and use appropriate vocabulary and numeric, symbolic, graphic, and linguistic modes of representation to communicate scientific ideas, plans, results, and conclusions (e.g., use historical and current weather data to support a position on future weather patterns); investigate factors which affect the development, severity, and movement of global and local weather systems (e.g., the ozone layer, El Niño, bodies of water, glaciers, smog, rain forests).

Paragraph 28
By the end of this course, students will: identify and describe the principal characteristics of the hydrosphere and the four regions of the atmosphere; describe and explain heat transfer within the water cycle and how the hydrosphere and atmosphere act as heat sinks; describe and illustrate the factors affecting heat transfer within the water cycle in the atmosphere (e.g., temperature, pressure, humidity, winds); observe, through experiment and simulation, and describe (a) the effects of atmospheric pressure, (b) the pattern of air movement in convection, (c) the phenomenon of inversion, (d) the greenhouse effect, and (e) heat transfer through radiation (e.g., (a) the reduction of the boiling point of water with reduced presssure or altitude; (c) the formation of dew or frost early in the morning following a clear calm night; (e) the use of dark solar panels for effective heat transfer); describe the factors relating to the rotation of the Earth that cause the movement of air

masses and variations in the Earth's temperature; describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water currents; describe and explain the effects of heat transfer within the hydrosphere and atmosphere on the development, severity, and movement of weather systems (e.g., effects such as pressure gradients, cloud formation, winds).

Paragraph 10
By the end of this course, students will: through investigations and applications of basic concepts: formulate scientific questions about observed ecological relationships, ideas, problems, and issues (e.g., "What impact will supplying an excess of food for a particular organism have on an ecosystem?"); demonstrate the skills required to plan and conduct an inquiry into ecological relationships, using instruments, apparatus, and materials safely and accurately, and controlling major variables and adapting or extending procedures where required; select and integrate information from various sources, including electronic and print resources, community resources, and personally collected data, to answer the questions chosen; analyse data and information and evaluate evidence and sources of information, identifying flaws such as errors and bias; select and use appropriate vocabulary and numeric, symbolic, graphic, and linguistic modes of representation to communicate scientific ideas, plans, results, and conclusions (e.g., use terms such as biotic, abiotic, biomass, biome, ecosystem, chemical concentration, and biodiversity when making presentations); design and conduct an investigation to examine the effects of one factor on soil composition and fertility and on water quality in an ecosystem (e.g., design and conduct an experiment to examine the effects of altering soil pH on the fertility of plants and on the concentration of dissolved oxygen in water, and graph the results); analyse a population case study (e.g., of deer, wolves, or humans) by producing population growth curves for each of the populations in the study, and use the graphs to explain how different factors affect population size and to predict the effect of varying factors (e.g., the availability of food) on the population.

Paragraph 42
By the end of this course, students will: through investigations and applications of basic concepts: formulate scientific questions about observed relationships, ideas, problems, and issues related to motion (e.g., "What are the different acceleration characteristics of different transportation vehicles?"); demonstrate the skills required to plan and conduct an inquiry into motion, controlling major variables and adapting or extending procedures where required (e.g., determine the time or distance intervals at which measurements should be taken to calculate the average velocity of a bicycle rider); use a broad range of tools and techniques safely, accurately, and effectively to compile, record, and analyse data and information, and apply mathematical and conceptual models to develop and assess possible explanations (e.g., stopwatches, photo-gates, length-measurement devices, and motion sensors to obtain data; electronic spreadsheets and graphs to record and analyse the data); select and integrate information from various sources, including electronic and print resources, to answer the questions chosen; analyse data and information and evaluate evidence and sources of information, identifying flaws such as errors and bias (e.g., determine the mathematical relationship among displacement, velocity, and time, and identify any sources of error in data collection); identify, explain, and express sources of error and uncertainty in experimental measurements; select and use appropriate vocabulary, SI units, and numeric, symbolic, graphic, and linguistic modes of representation to communicate scientific ideas, plans, results, and conclusions (e.g., present a graph showing an object's velocity, ensuring that the variables are on the appropriate axis); design, conduct, and evaluate experiments to measure the displacement, velocity, and acceleration of a moving object in one dimension, for both uniform motion and constant

acceleration; design, conduct, and evaluate an experiment to measure acceleration due to gravity; use simple graphs and vector diagrams to describe predicted and observed motion in one dimension.

Science SNC4M Science, Grade 12, University/College Preparation

Geospatial concepts: demographics, distribution of natural resources, GPS, scale, symbolic

Paragraph 25
By the end of this course, students will: describe some of the means used by agencies and governments to control the spread of disease, both locally and globally; evaluate the impact on an individual and on society of the misuse of antibiotics in the control of infection (e.g., chart the cause-and-effect relationships between the use of antibiotics and vaccines and the development of viral mutations and resistant strains of bacteria); research and explain the impact on disease control of technological advances in food preparation and preservation (e.g., the impact of freezing, pasteurization, radiation, and canning on food marketing); describe aseptic techniques used in the workplace and explain their importance (e.g., the techniques used to prevent food poisoning or the spread of disease in a food preparation facility or a restaurant); research and describe the impact on populations of the use of new technologies to control disease (e.g., gather and integrate information on community demographics and rates of infant survival to illustrate the effect over time of new vaccines and antibiotics).

Paragraph 21
By the end of this course, students will: identify, based on information integrated from print and electronic sources, short- and long-term environmental effects of by-products from nuclear generating stations; identify new energy applications inspired by traditional energy sources (e.g., battery-operated cars including those powered by fuel cells); evaluate the environmental impact of a specific alternative source of energy (e.g., conduct an environmental impact survey that covers such issues as costs and waste production/management); analyse the costs and benefits to society of alternative energy systems, and assess the impact of their use on a global scale (e.g., wind generators, or tidal power plants); evaluate the suitability of alternative energy sources, using research into the regional availability of natural resources in Canada (e.g., draw a correlation map for Canada showing regional energy systems and the distribution of natural resources, including water, fossil fuels, heat sinks, and wind and tides).

Paragraph 45
By the end of this course, students will: define, with examples when appropriate, terms such as: wave, wavelength, frequency, semi-conductor, electromagnetic spectrum, fibre optic cabling; identify and describe the technologies involved in various communications systems (e.g., technologies involved in the Global Positioning System [GPS], or the Internet); explain the fundamental scientific principles related to the use of a communications technology (e.g., fibre optics in a communications system); explain, based on information from print and electronic sources, how electromagnetic radiation, as a form of energy, is produced and transmitted (e.g., radio waves); identify and describe (e.g., outline, in a concept diagram) the properties and applications of the various regions of the electromagnetic spectrum; identify and describe the applications of the electromagnetic spectrum in communications systems (e.g., radio, television, telephone, radar, satellites, fibre optics, or converters); identify and explain the application of semi-conductors in communications systems (e.g., the use of semi-conductors in computers and graphic projection

devices); explain the energy transformations that take place to permit the transmission and reception of signals in communications systems; describe how sound energy is received, analysed, and reproduced electronically (e.g., energy transformations in the functioning of a microphone).

Paragraph 37
By the end of this course, students will: identify, based on information integrated from print and electronic sources, short- and long-term environmental effects of by-products from nuclear generating stations; identify new energy applications inspired by traditional energy sources (e.g., battery-operated cars including those powered by fuel cells); evaluate the environmental impact of a specific alternative source of energy (e.g., conduct an environmental impact survey that covers such issues as costs and waste production/management); analyse the costs and benefits to society of alternative energy systems, and assess the impact of their use on a global scale (e.g., wind generators, or tidal power plants); evaluate the suitability of alternative energy sources, using research into the regional availability of natural resources in Canada (e.g., draw a correlation map for Canada showing regional energy systems and the distribution of natural resources, including water, fossil fuels, heat sinks, and wind and tides).

Technological Education TTJ3C Transportation Technology, Grade 11, College Preparation

Geospatial concepts: demographics, distance, movement, region, scale drawing/model

Paragraph 31
By the end of this course, students will: describe the consequences of transportation technology for individuals and for society (e.g., by conducting a survey to document how an efficient mass-transit system affects the travel time for a commuter, or by investigating the demographics of commuting and identifying whether the current mass-transit system in their region could handle the anticipated population growth over the next five years); describe the possible impact of transportation technology on the environment; identify a variety of materials, processes, and waste-management methods that would minimize the negative impact of a transportation-related activity

Paragraph 11
By the end of this course, students will: describe the importance of transportation systems to maintaining our quality of life; explain how people and goods are moved by highway, air, rail, water, and pipeline transportation systems; describe the importance of distance, weight, and volume when selecting the most cost-efficient means of transporting goods; explain how comfort and speed relate to the selection of the most cost-efficient means of transporting people

Paragraph 6
By the end of this course, students will: apply the design process to develop solutions, products, processes, or services in response to challenges or problems in transportation technology; describe how materials and processes are used to produce solutions to meet human needs and wants related to transportation; identify the impact of the movement of people and goods on vehicle systems and modes of transportation (highway, rail, air, water, pipeline); describe the forms of energy used to power vehicles and transportation systems and explain the different types of energy conversion used for each.

Paragraph 31
By the end of this course, students will: describe the consequences of transportation technology for individuals and for society (e.g., by conducting a survey to document how an efficient mass-transit system affects the travel time for a commuter, or by investigating the demographics of commuting and identifying whether the current mass-transit system in their region could handle the anticipated population growth over the next five years); describe the possible impact of transportation technology on the environment; identify a variety of materials, processes, and waste-management methods that would minimize the negative impact of a transportation-related activity.

Paragraph 19
By the end of this course, students will: develop systems for production, marketing, personnel, and financial control related to transportation systems; use computers to help develop, operate, and control transportation systems; sketch appropriate solutions to defined problems to scale showing orthographic and isometric views; use fabrication techniques to mock up or model potential solutions to a transportation technology challenge; test materials and products to develop the best solution to a transportation technology challenge; select and use appropriate software to develop marketing strategies for a solution to a transportation technology challenge.

Figure 9: Examples of cross-curricular activities incorporated with geospatial concepts

Family Studies
Geospatial concepts: map making, symbol, spatial pattern

Objective: to research a country and main food imported into Canada

Activities:

1. Maps: source and destination of food/agricultural products. This builds on spatial knowledge, symbols, visual patterns, thematic maps and Internet use.
2. Processing: research the processing of the agricultural product-present using flow diagrams. This builds on spatial knowledge, classification and primary/secondary source/information.
3. Cook with food/agricultural product: find a recipe from the area and prepare it for the class. This builds on symbols, measure, time, accuracy/precision, scale
4. Cultural/Historical Significance: research the agricultural product and produce a paper identifying he significance of the produce to the region/country. This builds on quantitative/qualitative data, primary/secondary information

Mathematics
Geospatial concepts: scale

Objective: to learn scale through model building

Activity: Draw a scale diagram of floor plan (in AutoCad). Then, build a scale model of this house.

Native Studies
Geospatial concepts: location

Objective: For students to be aware that specific of location has influence on images/themes in indigenous literature. Explain how location influences world view.

Procedure: Each group of 4 students get 3 stories from our culture and a piece on physical geography

Assignment: Based on reading, describe how the environment is reflected in literature. How does my environment influence my world view (locate, spatial and cultural patterns created).

Appendix 1: List of 160 course documents from the Ontario Curriculum

Subject	Course Code	Name of document
Business Studies	BAF3M	Introduction to Financial Accounting, Grade 11, University/College Preparation
Business Studies	BAI3E	Introduction to Accounting, Grade 11, Workplace Preparation
Business Studies	BAN4E	Accounting for a Small Business, Grade 12, Workplace Preparation
Business Studies	BAT4M	Principles of Financial Accounting, Grade 12, University/College Preparation
Business Studies	BBB4E	Introduction to International Business, Grade 12, Workplace Preparation
Business Studies	BBB4M	Introduction to International Business, Grade 12, University/College Preparation
Business Studies	BBI1O-BBI2O	Introduction to Business, Grade 9 or 10, Open
Business Studies	BDI3C	Introduction to Entrepreneurial Studies, Grade 11, College Preparation
Business Studies	BDP3O	The Enterprising Person, Grade 11, Open
Business Studies	BDV4C	Entrepreneurial Studies: Venture Planning, Grade 12, College Preparation
Business Studies	BMI3C	Introduction to Marketing, Grade 11, College Preparation
Business Studies	BMX3E	Introduction to Retail and Services Marketing, Grade 11, Workplace Preparation
Business Studies	BOG4E	Organizational Studies: Managing a Small Business, Grade 12, Workplace Preparation
Business Studies	BOH4M	Organizational Studies: Organizational Behaviour and Human Resources, Grade 12, University/College Preparation
Business Studies	BTA3O	Information Technology Applications in Business, Grade 11, Open
Business Studies	BTT1O-BTT2O	Introduction to Information Technology in Business, Grade 9 or 10, Open
Business Studies	BTX4C	Information Technology in Business, Grade 12, College Preparation
Business Studies	BTX4E	Information Technology in Business, Grade 12, Workplace Preparation
Canadian and World Studies	CGC1D	Geography of Canada, Grade 9, Academic
Canadian and World Studies	CGC1P	Geography of Canada, Grade 9, Applied
Canadian and World Studies	CGD3M	The Americas: Geographic Patterns and Issues, Grade 11, University/College Preparation
Canadian and World Studies	CGF3M	Physical Geography: Patterns, Processes, and Interactions, Grade 11, University/College Preparation
Canadian and World Studies	CGG3O	Regional Geography: Travel and Tourism, Grade 11, Open
Canadian and World Studies	CGO4M	Geomatics: Geotechnologies in Action, Grade 12, University/College Preparation
Canadian and World Studies	CGR4E	The Environment and Resource Management, Grade 12, Workplace Preparation
Canadian and World Studies	CGR4M	The Environment and Resource Management, Grade 12, University/College Preparation
Canadian and World Studies	CGT3E	Geographics: The Geographer's Toolkit, Grade 11, Workplace Preparation
Canadian and World Studies	CGU4C	World Geography: Urban Patterns and Interactions, Grade 12, College Preparation

Canadian and World Studies	CGU4U	World Geography: Human Patterns and Interactions, Grade 12, University Preparation
Canadian and World Studies	CGW4U	Canadian and World Issues: A Geographic Analysis, Grade 12, University Preparation
Canadian and World Studies	CHA3U	American History, Grade 11, University Preparation
Canadian and World Studies	CHC2D	Canadian History in the Twentieth Century, Grade 10, Academic
Canadian and World Studies	CHC2P	Canadian History in the Twentieth Century, Grade 10, Applied
Canadian and World Studies	CHH3C	Canadian History and Politics Since 1945, Grade 11, College Preparation
Canadian and World Studies	CHH3E	Canadian History and Politics Since 1945, Grade 11, Workplace Preparation
Canadian and World Studies	CHI4U	Canada: History, Identity, and Culture, Grade 12, University Preparation
Canadian and World Studies	CHM4E	Adventures in World History, Grade 12, Workplace Preparation
Canadian and World Studies	CHT3O	Twentieth-Century History: Global and Regional Perspectives, Grade 11, Open
Canadian and World Studies	CHW3M	World History to the Sixteenth Century, Grade 11, University/College Preparation
Canadian and World Studies	CHY4C	World History: The West and the World, Grade 12, College Preparation
Canadian and World Studies	CHY4U	World History: The West and the World, Grade 12, University Preparation
Canadian and World Studies	CIA4U	Analysing Current Economic Issues, Grade 12, University Preparation
Canadian and World Studies	CIC3E	Making Economic Choices, Grade 11, Workplace Preparation
Canadian and World Studies	CIE3M	The Individual and the Economy, Grade 11, University/College Preparation
Canadian and World Studies	CLN4U	Canadian and International Law, Grade 12, University Preparation
Canadian and World Studies	CLU3E	Understanding Canadian Law, Grade 11, Workplace Preparation
Canadian and World Studies	CLU3M	Understanding Canadian Law, Grade 11, University/College Preparation
Canadian and World Studies	CPC3O	Canadian Politics and Citizenship, Grade 11, Open
Canadian and World Studies	CPW4U	Canadian and World Politics, Grade 12, University Preparation
Social Sciences and the Humanities	HFA4M	Food and Nutrition Sciences, Grade 12, University/College Preparation
Social Sciences and the Humanities	HFN1O-HFN2O	Food and Nutrition, Grade 9 or 10, Open
Social Sciences and the Humanities	HHG4M	Issues in Human Growth and Development, Grade 12, University/College Preparation

Social Sciences and the Humanities	HHS4M	Individuals and Families in a Diverse Society, Grade 12, University/College Preparation
Social Sciences and the Humanities	HIF1O-HIF2O	Individual and Family Living, Grade 9 or 10, Open
Social Sciences and the Humanities	HIP3E	Managing Personal Resources, Grade 11, Workplace Preparation
Social Sciences and the Humanities	HIR3C	Managing Personal and Family Resources, Grade 11, College Preparation
Social Sciences and the Humanities	HLS3O	Living Spaces and Shelter, Grade 11, Open
Social Sciences and the Humanities	HNB4O	The Fashion Industry, Grade 12, Open
Social Sciences and the Humanities	HNC3O	Fashion and Creative Expression, Grade 11, Open
Social Sciences and the Humanities	HPC3O	Parenting, Grade 11, Open
Social Sciences and the Humanities	HPD4E	Parenting and Human Development, Grade 12, Workplace Preparation
Social Sciences and the Humanities	HPW3C	Living and Working With Children, Grade 11, College Preparation
Social Sciences and the Humanities	HRF3O	World Religions: Beliefs and Daily Life, Grade 11, Open
Social Sciences and the Humanities	HRT3M	World Religions: Beliefs, Issues, and Religious Traditions, Grade 11, University/College Preparation
Social Sciences and the Humanities	HSB4M	Challenge and Change in Society, Grade 12, University/College Preparation
Social Sciences and the Humanities	HSP3M	Introduction to Anthropology, Psychology, and Sociology, Grade 11, University/College Preparation
Social Sciences and the Humanities	HZB3O	Philosophy: The Big Questions, Grade 11, Open
Social Sciences and the Humanities	HZT4U	Philosophy: Questions and Theories, Grade 12, University Preparation
Mathematics	MAP4C	College and Apprenticeship Mathematics, Grade 12, College Preparation
Mathematics	MBF3C	Mathematics of Personal Finance, Grade 11, College Preparation
Mathematics	MCB4U	Advanced Functions and Introductory Calculus, Grade 12, University Preparation
Mathematics	MCF3M	Functions, Grade 11, University/College Preparation
Mathematics	MCR3U	Functions and Relations, Grade 11, University Preparation
Mathematics	MCT4C	Mathematics for College Technology, Grade 12, College Preparation
Mathematics	MDM4U	Mathematics of Data Management, Grade 12, University Preparation
Mathematics	MEL3E	Mathematics for Everyday Life, Grade 11, Workplace Preparation
Mathematics	MEL4E	Mathematics for Everyday Life, Grade 12, Workplace Preparation
Mathematics	MFM1P	Foundations of Mathematics, Grade 9, Applied
Mathematics	MFM2P	Foundations of Mathematics, Grade 10, Applied
Mathematics	MGA4U	Geometry and Discrete Mathematics, Grade 12, University Preparation
Mathematics	MPM1D	Principles of Mathematics, Grade 9, Academic
Mathematics	MPM2D	Principles of Mathematics, Grade 10, Academic
Native Studies	NAC1O	Expressing Aboriginal Cultures, Grade 9, Open
Native Studies	NAC2O	Aboriginal Peoples in Canada, Grade 10, Open

Native Studies	NBE3C	English: Contemporary Aboriginal Voices, Grade 11, College Preparation
Native Studies	NBE3U	English: Contemporary Aboriginal Voices, Grade 11, University Preparation
Native Studies	NBV3C	Aboriginal Beliefs, Values, and Aspirations in Contemporary Society, Grade 11, College Preparation
Native Studies	NBV3E	Aboriginal Beliefs, Values, and Aspirations in Contemporary Society, Grade 11, Workplace Preparation
Native Studies	NDA3M	Current Aboriginal Issues in Canada, Grade 11, University/College Preparation
Native Studies	NDG4M	Aboriginal Governance: Emerging Directions, Grade 12, University/College Preparation
Native Studies	NDW4M	Issues of Indigenous Peoples in a Global Context, Grade 12, University/College Preparation
Health and Physical Education	PLF4C	Recreation and Fitness Leadership, Grade 12, College Preparation
Health and Physical Education	PPL1O	Healthy Active Living Education, Grade 9, Open
Health and Physical Education	PPL2O	Healthy Active Living Education, Grade 10, Open
Health and Physical Education	PPL3O	Healthy Active Living Education, Grade 11, Open
Health and Physical Education	PPL4O	Healthy Active Living Education, Grade 12, Open
Health and Physical Education	PPZ3O	Health for Life, Grade 11, Open
Health and Physical Education	PSE4U	Exercise Science, Grade 12, University Preparation
Science	SBI3C	Biology, Grade 11, College Preparation
Science	SBI3U	Biology, Grade 11, University Preparation
Science	SBI4U	Biology, Grade 12, University Preparation
Science	SCH3U	Chemistry, Grade 11, University Preparation
Science	SCH4C	Chemistry, Grade 12, College Preparation
Science	SCH4U	Chemistry, Grade 12, University Preparation
Science	SES4U	Earth and Space Science, Grade 12, University Preparation
Science	SNC1D	Science, Grade 9, Academic
Science	SNC1P	Science, Grade 9, Applied
Science	SNC2D	Science, Grade 10, Academic
Science	SNC2P	Science, Grade 10, Applied
Science	SNC3E	Science, Grade 11, Workplace Preparation
Science	SNC3M	Science, Grade 11, University/College Preparation
Science	SNC4E	Science, Grade 12, Workplace Preparation
Science	SNC4M	Science, Grade 12, University/College Preparation
Science	SPH3U	Physics, Grade 11, University Preparation
Science	SPH4C	Physics, Grade 12, College Preparation
Science	SPH4U	Physics, Grade 12, University Preparation
Technological Education	ICE3E	Computer Engineering, Grade 11, Workplace Preparation
Technological Education	ICE3M	Computer Engineering, Grade 11, University/College Preparation
Technological	ICE4E	Computer Engineering, Grade 12, Workplace Preparation

Education		
Technological Education	ICE4M	Computer Engineering, Grade 12, University/College Preparation
Technological Education	ICS3M	Computer and Information Science, Grade 11, University/College Preparation
Technological Education	ICS4M	Computer and Information Science, Grade 12, University/College Preparation
Technological Education	TCJ2O	Construction Technology, Grade 10, Open
Technological Education	TCJ3E	Construction Technology, Grade 11, Workplace Preparation
Technological Education	TCJ4C	Construction Technology, Grade 12, College Preparation
Technological Education	TCJ4E	Construction Technology, Grade 12, Workplace Preparation
Technological Education	TDJ2O	Technological Design, Grade 10, Open
Technological Education	TDJ3E	Technological Design, Grade 11, Workplace Preparation
Technological Education	TDJ3M	Technological Design, Grade 11, University/College Preparation
Technological Education	TDJ4E	Technological Design, Grade 12, Workplace Preparation
Technological Education	TDJ4M	Technological Design, Grade 12, University/College Preparation
Technological Education	TEE2O	Computer Engineering Technology, Grade 10, Open
Technological Education	TFH3E	Hospitality and Tourism, Grade 11, Workplace Preparation
Technological Education	TFH4E	Hospitality and Tourism, Grade 12, Workplace Preparation
Technological Education	TFJ2O	Hospitality and Tourism Technology, Grade 10, Open
Technological Education	TFS4C	Tourism, Grade 12, College Preparation
Technological Education	TFT3C	Hospitality, Grade 11, College Preparation
Technological Education	TGJ2O	Communications Technology, Grade 10, Open
Technological Education	TGJ3E	Communications Technology, Grade 11, Workplace Preparation
Technological Education	TGJ3M	Communications Technology, Grade 11, University/College Preparation
Technological Education	TGJ4E	Communications Technology, Grade 12, Workplace Preparation
Technological Education	TGJ4M	Communications Technology, Grade 12, University/College Preparation
Technological Education	TIK2O	Computer and Information Science, Grade 10, Open
Technological Education	TMJ2O	Manufacturing Technology, Grade 10, Open
Technological Education	TMJ3C	Manufacturing Engineering Technology, Grade 11, College Preparation
Technological Education	TMJ3E	Manufacturing Technology, Grade 11, Workplace Preparation
Technological Education	TMJ4C	Manufacturing Engineering Technology, Grade 12, College Preparation

Technological Education	TMJ4E	Manufacturing Technology, Grade 12, Workplace Preparation
Technological Education	TPA3C	Health Care, Grade 11, College Preparation
Technological Education	TPE3E	Hairstyling and Aesthetics, Grade 11, Workplace Preparation
Technological Education	TPE4E	Hairstyling and Aesthetics, Grade 12, Workplace Preparation
Technological Education	TPJ2O	Health and Personal Services Technology, Grade 10, Open
Technological Education	TPO4C	Child Development and Gerontology, Grade 12, College Preparation
Technological Education	TPT4C	Medical Technologies, Grade 12, College Preparation
Technological Education	TTI1O	Integrated Technologies, Grade 9, Open
Technological Education	TTJ2O	Transportation Technology, Grade 10, Open
Technological Education	TTJ3C	Transportation Technology, Grade 11, College Preparation
Technological Education	TTJ3E	Transportation Technology, Grade 11, Workplace Preparation
Technological Education	TTJ4C	Transportation Technology, Grade 12, College Preparation
Technological Education	TTJ4E	Transportation Technology, Grade 12, Workplace Preparation