Catholic District School Board Writing Partnership

Canadian and World Studies

Course Profile

Geomatics: Geotechnologies in Action

Grade 12
University/College Preparation
CGO4M

• *for teachers by teachers*

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Course Overview
Geomatics: Geotechnologies in Action, CGO4M, Grade 12, University/College Preparation

Policy Document: *The Ontario Curriculum, Grades 11 and 12, Canadian and World Studies, 2000.*
Prerequisite: Any University, University/College, or College Preparation course in Canadian and World Studies, English, or Social Sciences and Humanities

Course Description

This course examines the approaches and techniques that geographers and other professionals use to acquire, manage, map, analyse, and communicate information about the earth's surface. Students will receive a systematic introduction to the four pillars of geomatics – surveying, remote sensing, cartography, and geographic information systems (GIS) – and will learn how to apply their knowledge and skills to a variety of real-world situations relating to physical and human geography. This University/College Preparation course is designed to equip students with the knowledge and skills they need to meet the expectations of a wide range of university and college level courses.

How This Course Supports the Ontario Catholic School Graduate Expectations

The Geomatics program in the Catholic faith community encourages students to develop skills and utilize their talents. A consistent theme found in the teachings of the Catholic Church concerns protecting and cherishing all life and creation. The Catholic Church teachings of Stewardship, Social Justice, and the principle of Common Good are imbedded in the critical analysis of problems faced by cultures around the world. The use of geotechnologies in the understanding and analysis of physical and human systems allows students to reflect on the implications of human actions on natural systems and to adopt a personal ethic as stewards of creation. The focus of the course enables students to be critical thinkers and innovative problem solvers and analyse the use of resources while understanding the implications of geotechnological innovations. The use of geotechnologies in global and local community studies reinforces the role of technology in promoting concepts of stewardship and sustainable resource use. The skills acquired in this course increase students' awareness of local and global events. These skills provide students with opportunities to make informed decisions and foster the development of a citizen based on the Catholic teachings of social responsibility. It is important for young Catholics to appreciate how geotechnologies can positively affect lives.

Course Notes

The Geomatics: Geotechnologies in Action course is considered an introduction to the field of geotechnology and its role within the discipline of geography. Geotechnology encompasses skills in the areas of global positioning systems (GPS), remote imagery, and geographic information systems (GIS) and is becoming a basic tool on the spatial side of information technology. Students continuing their studies in many disciplines, including geography, arts, and sciences, can benefit from the tools in this course.

> "Geomatics is a field of activities which, using a systemic approach, integrates all the means used to acquire and manage spatial data required as part of scientific, administrative, legal and technical operations involved in the process of the production and management of spatial information."
>
> Canadian Institute of Geomatics, 1998.

Geotechnology is not an end in itself; it is a skill set and methodology that allows students to improve their spatial skills throughout their academic and professional lives. For many years, GIS was a specialized field composed of professionals whose sole job was to build geographic databases, perform geographic analyses, and create maps. While many professionals specialize in GIS today, other people

use GIS as just one of the tools in their studies, such as a word processor or electronic spreadsheet. This course is designed for students to experience this technology and to gain a stronger appreciation of the world around them. The expectations have been clustered to allow for specific geographical focuses that include a range from global to local and from physical to human geography. Students gain an environmental awareness and gain a strong stewardship for their local area.

Students in CGO4M receive an introductory grounding in geotechnology and geomatics, which is a relevant addendum for any future studies. Students acquire experience in data collection, manipulation, interpretation, and display, all in a context of spatial and geographical analysis. It must be stressed that this is not a computer course; it is a geography course that makes use of geotechnology.

The technology used must be as up-to-date as possible. To this end, the technology is based on current ministry-licensed standard software. The Ministry of Education licenses two professional software programs that are currently in use within academia and industry throughout Ontario. These programs are uniquely different and have specific functions in the classroom as in private industry. *MFTeach,* a rastor-based program, is best suited for local and small area studies, whereas *Arcview* is a vector-based program and is used with studies of a regional, national, or global focus.

Computers: Ideally, this course should be based in a computer lab with GIS software programs, such as *ArcView, ArcCanada, ArcUSA,* and *MFTeach,* available. In many activities, students can use *MapInfo* as an alternative to *ArcView*.

Specific boards, schools, and programs throughout the province may use other GIS software packages. All of the activities in this profile can be adapted; however, students are progressing to college and/or university with an ultimate career goal. Teachers should use software that is used in postsecondary institutions or may be found in both public and private sectors.

The teacher in a GIS classroom is in a unique position. Because of the ever-changing world of computer software, the teacher is never as up-to-date as he/she would like to be. However, the teacher is there to guide students through the geographical and spatial skills inherent in any GIS. With respect to the geotechnical software, the teacher is positioned as a facilitator, guide, and co-learner. One of the greatest resources the teacher accesses is the interaction between teacher and students.

GIS is a major component of all the units in this course. Regular access to a computer lab, running a GIS program and providing Internet access, is essential. Adaptations can be made in some areas of the course; for example, students may share computers.

The units provide opportunities for students to explore significant components of geomatics. Unit 1 provides an introduction to the fundamentals of GIS theory. Unit 2 introduces students to a variety of imagery used in geographical analysis. Unit 3 attempts to link imagery and thematic mapping techniques together. Unit 4 provides an introduction to surveying skills, with special emphasis on GPS and its incorporation within geographical analysis. Unit 5, the culminating unit, provides students with the opportunity to demonstrate their skills, knowledge, understanding, and application of geotechology.

Units: Titles and Times

* Unit 1	The Fundamentals of Geomatics	20 hours
Unit 2	Geographic Concepts Using Imagery	20 hours
Unit 3	Analysing and Understanding Patterns of Information	25 hours
Unit 4	Using GPS and Other Geotechnologies	25 hours
Unit 5	Culminating Unit: Analysis of an Issue Using Geomatics and Geotechnologies	20 hours

* This unit is fully developed in this Course Profile.

Unit Overviews

Unit 1: The Fundamentals of Geomatics

Time: 20 hours

Unit Description

In this unit, students explore the structure and concepts used to construct both traditional maps and maps made with a GIS. Students gain an overall understanding of the history of map-making and the tools and techniques used for geographic analysis. Even though students use technology in map-making, the basic underlying principle is that the features on maps represent the natural phenomena on earth, thus reinforcing the Catholic social teaching of the sanctity of life. This unit should include a basic understanding of map projections and how manipulating map projections can alter our perception of the world. Students are introduced to the primary functional concepts of a GIS – map-making, using a variety of themes, ordering layers, using text annotations, and performing the layout of a map. Included with the understanding of a GIS is the introduction to complementary computer programs, such as spreadsheets, drawing software, and graphic packages, that are used in combination to produce well-designed and functional maps.

Strand(s): Geographic Foundations: Space and Systems, Human-Environment Interactions, Global Connections, Understanding and Managing Change, Methods of Geographic Inquiry

Unit Overview Chart

Activity	Learning Expectations	Assessment Categories	Focus
1	SSV.01, GI2.07, HEV.02, GC1.01, GCV.01 CGE2b, 7b	Knowledge/ Understanding Thinking/ Inquiry	Introduction to Geomatics
2	UCV.03, GC1.03, GC3.02, UC1.03, SS1.02, SS2.04, SS3.01 CGE2c, 3c, 3e	Knowledge/ Understanding Thinking/ Inquiry	History of Map-making – Development of Maps and Their Influence on Events
3	GCV.03, GI1.06, SSV.03, SS1.03, SS1.07, SS1.08 CGE1d, 3b	Application Communication	Map-making with a Purpose – Constructing Maps Using Components, such as Projections, to Convince Others of Your Point of View
4	GI1.12, SSV.02, GI1.14, GCV.02, GIV.03, GC3.03, SS2.01 CGE1d, 1i, 2e, 3f, 5a	Knowledge/ Understanding Thinking/ Inquiry	Introduction to GIS – Components of GIS and Their Uses
5	GI2.02 GIV.03, SS2.01 CGE1i, 3f, 5g	Knowledge/ Understanding Application	Georeferencing Images for Use in a GIS
6	GC3.04, SSV.04 CGE3c, 3b, 3d, 7b	Application	Constructing a World Map with Layers
7	GI1.07, GI2.10, GCV.01 CGE1d, 2a, 2b, 2c, 3c, 3f	Application Communication	Culminating Activity – Making a World Map Layout for Other Applications

Unit Culminating Activity

The focus of the culminating activity is the creation of a world map that is used in the geographic analysis of a specific issue. Students use basic geotechnical skills to measure both attribute and spatial parameters, i.e., this may include the location of specific places using latitude/longitude or UTM coordinates and/or analysis of the socio-demographic statistics to the specific places, present their findings in a properly constructed layout, and, from this map, make conclusions in light of the biblical concept of stewardship. Students should present their findings using a variety of map projections and analysis of how these projections influence the message of the map. Examples include mapping and analysing such issues as economic indicators or natural disaster identification. Students evaluate their ideas in light of the common good.

Unit 2: Geographic Concepts Using Imagery

Time: 20 hours

Unit Description

Using imagery, students use a GIS to explore and analyse the patterns and relationships that exist within world regions. Through a variety of image sources, students examine the world from the perspective of outer space transcending their subjective position on earth. Students witness the miracle of the earth's systems functioning and working together, reinforcing the concepts of interdependence and mutuality. Working with images from a variety of origins and scales, students develop an appreciation of the unique capability of satellite imagery. Students should be aware of how radar images differ from other images. Using aerial photographs, students identify and analyse the various components needed for interpretation.

Strand(s): Geographic Foundations: Space and Systems, Human-Environment Interactions, Global Connections, Understanding and Managing Change, Methods of Geographic Inquiry

Unit Overview Chart

Activity	Learning Expectations	Assessment Categories	Focus
1	GI1.13, UC2.02, UC1.01, HE1.01 CGE5b	Knowledge/ Understanding	Introduction to Rastor-Based Analysis – Image Fundamentals
2	GI1.08, GI1.09, GI1.10, SS1.06 CGE2b	Knowledge/ Understanding Application	Introduction to Satellite Capabilities – Kinds of Images, Platforms, Classification of Data, Methods of Collection, and Cloud Cover Problems
3	GC2.01, GC2.03 CGE3f	Application Communication	Working with Low-Resolution Images – World Satellite Images, WorldSat, and Night Image
4	GI1.15, GC3.01 CGE3b	Application	Combining Rastor and Vector Map Components
5	UC1.02, HE3.02, GC1.02, UC1.04 CCGE2d	Knowledge/ Understanding Thinking/Inquiry Communication	Exploring Canada's Contribution to Satellite Imagery – Radarsat Comparison to Other Satellite Images, Image Recognition and Cloud Cover Solutions in a GIS

Activity	Learning Expectations	Assessment Categories	Focus
6	GI2.12, GI1.10, HE1.02 CGE2e, 4f, 7i	Knowledge/ Understanding Thinking/Inquiry Application	Exploring High-Resolution Rastor Images Aerial Photos: Types, Application and Analysis in a GIS
7	UC2.03, GI2.11, GI1.11, GI3.02 CGE3c	Thinking/Inquiry Application	Detecting Change Through Image Analysis Using a GIS
8	HE1.03, HE3.03, UCV.01, UCV.02, UC3.02, SSV.05 CGE 1d, 5a, 7b	Thinking/Inquiry Application Communication	Using Satellite Images and GIS to Save Lives – Predicting the Paths of Natural Hazards

Unit Culminating Activity

The focus for the activity is the use of GIS and imagery to assess the level of damage caused by natural disasters which could threaten human life. Students use a GIS to calculate and display information where the damage from a disaster was greatest. Furthermore, students make predictions about the impact of the disaster on human systems. Students then provide an analysis based on the available data. They make recommendations that could be implemented to save human life in the event of a similar disaster, thereby reinforcing the concepts of interdependence and globalism and the value of the sanctity of life.

Unit 3: Analysing and Understanding Patterns of Information

Time: 25 hours

Unit Description

This unit highlights many principles of Catholic social teaching. Students identify and examine patterns that emerge from physical, human, and urban systems. Using a GIS, students have opportunities to map the relationships that exist between these systems. Through analysis of issues, students learn the dignity of human life and that our responsibility to each other crosses national, racial, economic, and ideological differences and that we are called to work for social justice. By exploring methods of data classification, students also map and appreciate the spatial distribution of unique human characteristics, such as ethnicity, indigenous peoples, and socio-economic patterns. The culminating activity focuses on urban patterns within cities. The socio-economic patterns in the city, such as crime, are mapped using a GIS.

Strand(s): Geographic Foundations: Space and Systems, Human-Environment Interactions, Global Connections, Understanding and Managing Change, Methods of Geographic Inquiry

Unit Overview Chart

Activity	Learning Expectations	Assessment Categories	Focus
1	HEV.01, HE1.02, SSV.04 CGE2b	Knowledge/ Understanding	Understanding the Elements of Physical Systems Using GIS – Defining Physical Regions
2	SSV.04, SS1.10 CGE4f	Knowledge/ Understanding Application	Mapping the Elements of Human Systems with a GIS
3	HEV.01, HE2.01, HE2.02, SS2.05, SS3.02	Thinking/Inquiry Communication	Using Images to Link Environmental and Human Systems in a GIS

Activity	Learning Expectations	Assessment Categories	Focus
4	GCV.02, GCV.03, GI1.03, GI2.13 CGE3f	Knowledge/ Understanding	Data Classification Methods and Technologies
5	HE3.01, SS3.03, GIV.01, GIV.02, GI2.13, UCV.01 CGE2c, 5a	Knowledge/ Understanding Application	Mapping the Distribution of Indigenous Peoples and Cultural Minorities Through GIS Mapping Structures
6	GIV.01, GIV.02, GIV.03, GI2.13, SS3.03 CGE3c	Knowledge/ Understanding Application	Using Data Classification Techniques to Find Patterns in Census Data
7	GCV.04, GC3.01, GIV.03 CGE1d	Knowledge/ Understanding Application	Applications of Street-Level Data
8	GIV.03, GCV.03 CGE1e, 4g	Thinking/Inquiry Communication	Exploring Urban Patterns with Street-Level Data
9	GCV.04, UC1.05 CGE1h, 2d, 5b	Communication	Culminating Activity: Crime in America – Integrating State, County, and Street-Level Data

Unit Culminating Activity

The purpose of the Unit 3 culminating activity is to acquaint students with the use of GIS and the role of GIS in law enforcement. Students examine patterns of crimes by state, by county, and at the street level. Students examine how GIS can help analyse patterns of crime in a community. They participate in a scenario whereby common social factors are attributed to an increase or decrease in crime rates. Similar geographic analyses occur every day in police departments across the United States and Canada. Students critically reflect on societal issues in light of gospel values and Catholic social justice teachings.

Unit 4: Using GPS and Other Geotechnologies

Time: 25 hours

Unit Description

This unit promotes complementary resources for a GIS, namely a Global Positioning System (GPS). During fieldwork, students use a GPS to collect data, input the data into a GIS, and then map the data in meaningful ways. Students use images overlaid with vector data to explore how GPS technologies can play a role in monitoring and predicting change in physical and human systems of geography. Students gain exposure to the use of these sources of information in limiting human problems associated with changes in the physical landscape. Students focus on the geotechnical skills of address geocoding, editing tables, editing vertices, merging and splitting polygons, and drawing features on maps. Hot-linking images to maps should also be accomplished by students. Using supporting technology, such as a GPS, students learn the importance of management of both physical and human systems. The teaching of the Church demonstrates how society is measured by its treatment of its most valuable resources and that there are social and environmental responsibilities fundamental to the preservation of life. As human beings, we have an ecological responsibility which flows from the dignity of all creation.

Strand(s): Geographic Foundations: Space and Systems, Global Connections, Understanding and Managing Change, Methods of Geographic Inquiry

Unit Overview Chart

Activity	Learning Expectations	Assessment Categories	Focus
1	GI1.05, SS1.04, GC3.05 CGE4b, 5b	Knowledge/ Understanding	Understanding the Fundamentals of GPS Technology
2	GI1.01, GI1.02, GI1.04, GI2.05, GI2.04, GI2.06, SS1.01, SS1.05 CGE2b, 4c, 4h, 7i	Knowledge Understanding Application	Developing Field Survey Skills Through GPS
3	GI2.09, UC2.01, SS2.02, SS2.03 CGE2b, 4c, 4h, 7i	Knowledge/ Understanding Application	Developing Map-Reading Skills with GPS, GIS, and Traditional Technologies
4	UC3.01, GC1.04, GC2.02 CGE2d, 4f	Knowledge/ Understanding Thinking/Inquiry	Using Local Images to Identify and Map Change
5	UC1.06, UC1.07, GC3.05 CGE2c, 4a, 5e, 5h	Thinking/Inquiry	Identifying Career Opportunities in Geomatics
6	GI2.08, GI3.01, GI3.03 CGE1d, 3e, 3f, 4g	Thinking/Inquiry Communication	Culminating Activity – Mapping Human Interactions in the Local Environment

Unit Culminating Activity

The purpose of this activity is to engage students in real-world analysis using their local area. Using the skills developed in this and previous units and under the direction of the teacher, students conceptualize a scenario using local data and situations. Subsequently, students develop a workable framework and execute a geographic analysis of their local area using a combination of GIS, GPS, imagery, and maps. Students present their findings either as a hard-copy report or as an electronic presentation.

Unit 5: Culminating Unit – Analysis of an Issue Using Geomatics and Geotechnology

Time: 20 hours

Unit Description

The student, in consultation with the teacher, plans, develops, and executes a study using techniques developed throughout the course. Apart from teacher consultation, this unit fosters leadership and encourages the responsibility of stewardship, which, according to the teachings of the Church, calls us to be good to the earth and each other.

Students demonstrate their skills with various geotechnologies and make informed conclusions on a specific issue using geomatic analysis. Students identify, plan, develop, and execute a study of a significant issue in the form of a report. This issue may include parameters of local, regional, or global significance. Students collect unique data from various sources to support their findings. The report should include:

- a series of maps and/or georeferenced images;
- a combination of student-researched data from various sources, including unique data;
- an explanation of the metadata used within this report;
- a geospatial and statistical analysis of the issue;
- conclusions regarding the issue in light of gospel values, such as the common good and stewardship.

The report should be presented in two ways, i.e., a paper report and visual presentation. Students may choose to integrate one or more techniques from each unit of study. The study should be manageable in scope so that students are able to finish their reports in the time allotted.

Strand(s): Human-Environment Interactions, Understanding and Managing Change, Methods of Geographic Inquiry

Unit Overview Chart

Activity	Learning Expectations	Assessment Categories	Focus
1	GI3.01, SSV.02 CGE4a, 5e	Knowledge/ Understanding Application	Developing a Scenario for a Geomatics Independent Study
2	GIV.03, GI1.02, GI12.01, GI2.03, GI3.03 CGE3c, 4f, 4g, 5b, 7i	Thinking/Inquiry	Gathering Information for Processing in a GIS
3	GIV.02, GI2.08, SS1.06, SS3.02, SS3.03 CGE2b, 3f, 5a	Application	Managing Data, Developing Maps, and Providing Analysis
4	GIV.02, GI1.07, UC3.01 CGE1d, 2c, 3e, 4c, 5h	Knowledge/ Understanding Application Communication	Developing Presentation Techniques
5	HEV.02, GCV.01, GCV.04, UCV.01, UCV.02, GI2.1 CGE4b, 4h, 2d	Communication	Presenting Solutions to Geomatics Scenarios

Teaching/Learning Strategies

This course lends itself to a variety of teaching and learning styles. These strategies encourage students to think critically, work cooperatively, and conduct research that has both an academic and practical value in their lives. Students should be given opportunities to investigate topics associated with current issues, recognizing the varying perspectives and postsecondary choices that could be made. Students should be encouraged to seek additional information to make informed choices about the paths available to them.

Learning Strategies: The teacher is encouraged to develop learning strategies that meet the needs of students with a wide variety of learning styles. Suggestions include research and data collection, guided Internet searches, structured tutorial-style lessons, simulations of real-life situations, collaborative learning, brainstorming, mind mapping, independent study, and personal reflection.

Teaching Strategies: The teacher should employ a number of strategies, including Socratic lessons, self-directed lessons, guest speakers, informed discussion, and presentations.

Demonstration: Students are asked to demonstrate a synthesis of their learning as they advance towards the culminating unit. During the culminating unit, students should be able to draw upon their previous experiences in the class, assimilate new information, and work towards a final summative performance.

Technical Skills: Students develop fundamental computer skills. They examine the historical development of geotechnologies and begin to understand the importance of these powerful tools. They develop their note-taking skills, demonstrate an understanding of various mapping conventions, and apply rudimentary computer-aided cartographic principles.

Geotechnical Skills: Students learn the major components and functional features of a GIS. They use a GIS to map a variety of world concerns. Students explore a variety of geographic concepts and gain skill in manipulating maps using industry-standard map-making software.

Global Application of Skills: Students are introduced to additional data sets and image manipulation. Students are guided through the ways geotechnologies can be employed to solve a variety of geographic problems. Central to this course is the investigation of ways that humans interact with their environment. Students extend their skills while exploring new concepts and patterns in the natural environment.

Local Application of Skills: Students explore a nearby area and choose a task of significance to them. They select an appropriate local study topic and then gather and analyse data to support the topic. Students utilize their skills to consolidate learning and develop business-like cartographic and presentation skills. If possible, students should make application through the lens of Catholic social teachings.

The subject of Geography and its associated geotechnologies use language in a unique way, especially language associated with computers and geotechnology. To help students, especially ESL/ELD students, the teacher should emphasize the following aspects of language in written and oral forms:

- specialized vocabulary;
- wide range of tense usage;
- words and phrases to indicate:
  - sequences or chronology;
  - cause-and-effect relationships;
  - contrast, comparison, and superlatives;
  - statements of opinion, interpretation, and inference;
  - statements of speculation, hypothesis, and prediction;
  - statements of belief persuasion, evaluation, and definition;
- formation of questions and problems for formal and informal circumstances;
- active listening skills;
- requests for repetition, clarification, and restatement;
- note taking and summarization.

Reading and listening activities require students to produce a specific and concrete product. Non-verbal communication skills are of particular importance to presentation tasks.

Language development and the expression of concepts are greatly facilitated if graphic products are reinforced with written or oral tasks and vice versa. All learners benefit greatly if the teacher initially provides models or structures for oral, written, and graphic communication.

Assessment & Evaluation of Student Achievement

Assessment and evaluation of student performance are based on the clusters of expectations for each of the focus activities in the Unit Overview Charts. Assessment and evaluation strategies measure a variety of student learning tasks, which are based upon the expectations outlined in the policy document. They are appropriate for assigned activities, and provide opportunities for students to assess and improve their own learning. The teacher makes use of information provided from the assessment process to critically evaluate whether the teaching strategies and overall program are effectively helping students to meet the expectations of the course. Teachers may have to develop some diagnostic tools to determine students' ability to proceed with certain technologically based strategies. Activities in the sample unit suggest both formative and summative evaluation strategies, as well as tools that teachers may employ in the classroom.

Throughout this course, various assessment methods, strategies, and tools are employed. They include:

- **Observation:** This method is used to monitor and assess the intellectual, social, emotional, and spiritual growth and development not otherwise easily measured. Techniques include anecdotal notes, student observation, formal and informal teacher observation, and rubrics.
- **Reflection:** This method is used to determine how and why students learn and to assess various dimensions of their learning not easily observed or measured through activities or tasks. Through student reflection, student understanding of personal growth and emotional development are assessed. Techniques include self-assessment and peer evaluation.
- **Conferencing:** Evidence of student learning, through listening, questioning, responding, and explaining, is assessed in student/teacher and parent/teacher conferences. Conferencing allows the teacher to assess communication and thinking skills and to monitor personal growth and development.
- **Paper-and-Pencil Tests:** Paper-and-pencil tests are administered throughout each unit. The teacher assesses student achievement of knowledge and skills that meet specific expectations for the course.
- **Performance Assessment:** Students' ability to effectively apply and communicate their knowledge and skills is assessed. Student achievement of specific expectations is also assessed. This method can be used to assess and provide opportunities for student improvement. Application and communication of knowledge and skills can be achieved through report writing, projects, use of geotechnologies (to collect, organize, and map data), presentations, demonstrations, graphic organizers, and portfolios.
- **Peer and Self-Editing:** Provides opportunities for students to improve by using assessment tools such as checklists and marking schemes.
- **Student Performance:** Adaptations to learning styles and special needs are incorporated into assessment to improve student performance and to ensure that each student is given clear directions for improvement, e.g., changing time requirements for completing assignments or assessments; changing the format of assessment; providing a quiet environment for assessment; simplifying test instructions and the language of questions; providing for the use of scribes, as well as allowing oral responses; providing alternative homework assignments; and basing classroom assessment on a full range of students' work.
- **Communication:** Assessment and evaluation must be communicated clearly to students and parents at the beginning of the course and at other appropriate points throughout the course. After assessment, feedback to students is essential.

Evaluation

The final summative evaluation for this course is broken into two parts. Unit 5 is a culminating unit based on a specific rich performance task (see Unit 5 Description), which brings together many of the expectations in an issues context. An examination is also required, using a GIS lab environment to allow student demonstration of the geotechnological skills and geomatic analysis specific to this course.

Seventy per cent of the grade will be based on assessments and evaluations conducted throughout the course. Thirty per cent of the grade will be based on a final evaluation in the form of a seminar-style performance, an essay, and an examination in a GIS lab environment.

Accommodations

Teachers should be aware of students who require adaptations to the expectations. *Ontario Secondary Schools* allows teachers to adapt the learning expectations for exceptional students in support of the contents of students' Individual Education Plans (IEPs). Care must be taken to avoid risk to the credit. The advice of the principal should be sought. This applies also to students who have not been identified as exceptional but are receiving special education programs and services.

Exceptional Students: Effort is made to assist students in achieving success in this course. Specific adaptations and accommodations are recommended with each activity. IEPs for exceptional students provide teachers with specific learning strategies and recommendations for instruction.

- The teacher should review students' IEPs and decide the best course of action for meeting expectations. An additional resource for teachers is the *Curriculum Planner* Special Education Accompaniment.

Enrichment: There are numerous opportunities throughout the course for enrichment. While this course is mainly vector-based mapping, students should be encouraged to explore rastor-based programs. Students should also be encouraged to investigate extensions to the basic GIS software.

ESL/ELD Learners: Many assessment tools for ESL/ELD students are formative, both in the assessment of understanding of concepts and the acquisition and practice of the specifically identified language forms necessary to express the concepts. The ESL/ELD learners' self-esteem and motivation to learn benefit when strategies allow expression of their individual skills, interests, and life experiences in their families, communities, and countries of origin. Sensitivity to the diversity of cultural, ethnic, and religious beliefs and the customs, socio-economic levels, and family structures of students entails accommodations to the structuring of learning experiences and resources. Subjects are presented in ways that focus on their relevance to ESL/ELD students' needs, be they communicative, such as language, day-to-day survival, social, physical, emotional, or cognitive. The proficiency levels outlined in *The Ontario Curriculum, Grades 9-12, Eng1ish As a Second Language and English Literacy Development* provide the teacher with a guide to receiving and accommodating these learners in the regular classroom.

Resources

Units in this Course Profile make reference to the use of specific texts, magazines, films, videos, and websites. The teachers need to consult their board policies regarding use of any copyrighted materials. Before reproducing materials for student use from printed publications, teachers need to ensure that their board has a Cancopy licence and that this licence covers the resources they wish to use. Before screening videos/films with their students, teachers need to ensure that their board/school has obtained the appropriate public performance videocassette licence from an authorized distributor, e.g., Audio Cine Films Inc. Teachers are reminded that much of the material on the Internet is protected by copyright. The copyright is usually owned by the person or organization that created the work. Reproduction of any work or substantial part of any work from the Internet is not allowed without the permission of the owner.

Software

ESRI Canada. *ArcView 3.X.* Obtainable through Board OESS rep.

MFTeach. Thinkspace Inc. Obtainable through Board OESS rep.

Software Support Websites

ESRI CANADA K to 12 Program – www.esricanada.com/k-12/gis/capabilities.html

MF Teach – www.MFTEACH.com

Video

ESRI. *Data for Decision*. Can Roger Tomlinson, 1968. 20 min.

ESRI. *Geography Matters*. ESRI Can, 1998. 5 min.

ESRI. *The District. Using GIS to Combat Crime*. 2001. 5 min.

CD-ROMs

ATLAS Ontario. 2001. Obtainable through ESRI Canada.

ESRI Canada. *ArcCanada v.2 or 3.* Obtainable through Board OESS rep.

Geographer's Workbench. Obtainable through GEM Geotechnologies

GeoKit. OAGEE, 1999. Obtainable through OAGEE regional rep.

Ontario Ministry of Natural Resources. *CD of Selected Ontario Base Maps and Layered Data*. ESRI Canada, spring 2001.

Ontario Ministry of Education. *Canadian Geographic Explorer*. Special Edition Irwin Publishing, 2000.

Websites

The URLs for the websites were verified by the writers prior to publication. Given the frequency with which these designations change, teachers should always verify the websites prior to assigning them for student use.

Canada Soils and Agriculture – http://sis.agr.ca/CANIS/

Canadian Council on Geographic Education – www.ccge.org

Canadian Data and Images – www.nrcan.gc.ca

Canadian Schools Atlas Project: Info by and for Canadian students – http://cgdi.gc.ca/ccatlas

Canadian Space Agency – www.space.gc.ca/csa

Canadian Statistics – http://www.statcan.ca/english/Estat/licence.htm

Federal (FEMA) Emergency Management Agency US Natural Hazards – www.gismaps.fema.gov

Geography network, free world data – www.geographynetwork.com

Geogratis free national data site – http:// geogratis.cgdi.gc.ca

Geomatics Industry – http://www.geomatics.org

Images of Canada and the World: Canadian Centre for Remote Sensing – www.ccrs.nrcan.gc.ca

Information and surveys of world issues – www.planetproject.ca

NASA Data and Images – www.jpl.nasa.gov

National Geographic – www.nationalgeographic.com

Network (Shaping a New World) – www.network.org

Ontario Association for Geographic and Environmental Education magazine *Monograph* – www.oagee.org

Portal to GIS info – www.gis.com

The Royal Canadian Geographic Society – www.rcgs.org

Print and Reference

ArcView GIS ESRI Canada Manual.

Audet, Richard and Gail Ludwig. *GIS in Schools*. ESRI Press, 2000. ISBN 1-879102-85-4

Clark, Bruce and John Wallace. *Making Connections*. Scarborough, ON: Prentice Hall Ginn Canada, 1999. ISBN 0130126357

Celebrating an Education for Justice and Peace: A Letter to the Catholic Secondary School Students of Ontario from the Catholic Bishops of Ontario. Ontario Conference of Catholic Bishops, 01/96.

Davis, Bruce E. *GIS – A Visual Approach*. Onword Press. ISBN 1-56690-098-0

Davis, David E. *GIS for Everyone*. ESRI Press, 1999. ISBN 1-879102-49-8

Getting to Know ArcView GIS, 3rd ed. ESRI Press. ISBN 1879102-46-3

Getting to Know Desktop GIS. ESRI Press. ISBN 1-879102-42-0

Haddad, A. and C. *Teach Yourself PowerPoint 97*. Sams Pub. ISBN 0-672 31117-8

Hohl, Pat and Brad Mayo. *ArcView GIS Exercise Book, 2nd ed*. Onword Press. ISBN 1-56690-124-3

Hutchinson, Scott and Larry Daniel. *Inside ARCVIEW GIS, 2nd ed.* Onword Press. ISBN 1-56690-116-2

Mitchell, Andy. *The ESRI Guide to GIS Analysis: Volume 1: Geographic Patterns & Relationships*. ESRI Press. ISBN 1-879102-06-4

Nicolucci, J. and Rex Taylor. *ArcView GIS Workbook & Teacher's Guide*. Crescent School, ON. Phone 416-449 2556, ext 239.

Pottle, Todd. *Geography and GIS: GIS Activities for Students*. Toronto: Irwin Publishing, 2001. ISBN 0-7725-2830-6

Shaping A New World: A Challenge for 21st Century, 6th ed. A National Catholic Social Justice Lobby.

OSS Considerations

This profile is designed to assist teachers in developing and delivering Geomatics: Geotechnologies in Action, Grade 12, University/College Preparation, based on *The Ontario Curriculum, Grades 11 and 12, Canadian and World Studies, 2000* pp. 93-100. With reference to the requirements for the Ontario Secondary School Diploma, students can use this course as an additional compulsory credit or as one of the twelve optional credits identified in *Ontario Secondary Schools, Grades 9-12, Program and Diploma Requirements, 1999.* Expectations for accommodations and modifications are outlined in section 7.12 (pp. 56-58) and appendix 6 (pp.74-75). The basis for assessment, evaluation, and reporting practices is outlined on pp. 13-16 of *The Ontario Curriculum, Grades 9-12, Program Planning and Assessment, 2000*. Career exploration is a component of the course and is aligned with *Choices Into Action: Guidance and Career Education Policy for Elementary and Secondary Schools, 1999.*

This course integrates technology across the curriculum, i.e., use of the Internet in research, geographic information systems, and global positioning systems. The teacher should also integrate the values of stewardship, respect, and other common Christian values in analysing and solving issues in this course.

Coded Expectations, Geomatics: Geotechnologies in Action, Grade 12, University/College Preparation, CGO4M

Geographic Foundations: Space and Systems

Overall Expectations

SSV.01 · explain how the earth is modelled for scientific and mapping purposes;
SSV.02 · demonstrate an understanding of basic spatial concepts;
SSV.03 · explain the process of map projection and the properties and uses of selected projections;
SSV.04 · explain the use of geotechnologies in studying physical and human systems;
SSV.05 · use geotechnologies effectively to display and analyse patterns and regions on the earth's surface.

Specific Expectations

Understanding Concepts

SS1.01 – explain how the shape of the earth relates to the earth's rotation and gravitational field;
SS1.02 – explain the concepts of reference ellipsoid, reference sphere, and datum;
SS1.03 – define great circles, small circles, meridians, and parallels and explain the concept of great circle distance;
SS1.04 – explain the concept of elevation measured from mean sea level;
SS1.05 – differentiate between true, magnetic, and grid directions;
SS1.06 – demonstrate an understanding of the concept of scale, including the distinctions between large and small scale and between data scale and display scale;
SS1.07 – differentiate between spatial and non-spatial data; point, line, and area data; and qualitative and quantitative data;
SS1.08 – explain how map projections are used to transform the curved surface of the earth into a flat map, using examples from four broad groups of projections: azimuthal, conical, cylindrical, and miscellaneous;
SS1.09 – describe applications of geotechnologies relating to physical systems (e.g., resource management, climate modelling, forest mapping);
SS1.10 – describe applications of geotechnologies relating to human systems (e.g., marketing, route planning, precision farming, land use planning).

Developing and Practising Skills

SS2.01 – express location correctly by geographic coordinates, grid coordinates, and other methods (e.g., street address, postal code);
SS2.02 – express directions correctly as bearings (quadrant method) and azimuths (whole circle method) and convert from one to another;
SS2.03 – express scale correctly in numerical, verbal, and graphical form and convert from one to another;
SS2.04 – classify map projections as azimuthal, conical, or cylindrical based on the appearance of the meridians and parallels;
SS2.05 – analyse patterns of physical geography (e.g., relief, drainage) and human geography (e.g., settlements, land subdivision) on topographic maps and images.

Learning Through Application

SS3.01 – describe the properties and uses of important map projections, especially those commonly used in Canada (e.g., the Transverse Mercator and the Lambert Conformal);

SS3.02 – produce well-designed thematic maps to display and analyse distributions of physical and human phenomena (e.g., precipitation, population density, personal income);

SS3.03 – perform appropriate GIS analyses to isolate areas that meet specific criteria (e.g., orchards on sandy soil more than one hundred metres from a highway).

Human-Environment Interactions

Overall Expectations

HEV.01· explain the use of geotechnologies in studying human-environment interactions;

HEV.02 · evaluate the effectiveness of geotechnologies in identifying environmental problems and finding solutions.

Specific Expectations

Understanding Concepts

HE1.01 – explain the role of geotechnologies in facilitating the efficient and responsible use of resources (e.g., forests, minerals, fisheries);

HE1.02 – explain the role of geotechnologies in addressing environmental problems resulting from human action (e.g., pollution, deforestation, species extinction);

HE1.03 – explain the role of geotechnologies in addressing human problems caused by environmental forces (e.g., hurricanes, floods, avalanches).

Developing and Practising Skills

HE2.01 – explain the capability of GIS to integrate physical and human factors in addressing problems that involve aspects of both;

HE2.02 – relate patterns of physical geography (e.g., relief, drainage) to patterns of human geography (e.g., settlements, land subdivision) on maps and images.

Learning Through Application

HE3.01 – assess the role of geotechnologies in addressing issues affecting indigenous peoples (e.g., reserve management, resource inventories);

HE3.02 – evaluate the use of geotechnologies in sparsely populated areas (e.g., use of global positioning systems [GPS] in search-and-rescue operations, satellite monitoring of military activity, radar imaging of forests);

HE3.03 – assess whether modern geotechnologies could have been used to avert famous disasters (e.g., sinking of the Titanic, collapse of the Ocean Ranger drilling platform).

Global Connections

Overall Expectations

GCV.01 · explain the use of geotechnologies in addressing issues of global concern;

GCV.02 · explain the role of geotechnologies in understanding peoples and places around the world;

GCV.03 · analyse how perceptions of places, situations, and events are affected by maps;

GCV.04 · evaluate the role of geotechnologies in facilitating interaction, cooperation, and communication between peoples.

Specific Expectations

Understanding Concepts

GC1.01 – explain the role of geotechnologies in addressing issues affecting the world as a whole (e.g., global warming, overpopulation, warfare);

GC1.02 – describe the use of radar in providing information about cloud-covered parts of the earth;

GC1.03 – explain how map projection distortions can misrepresent the relative areas of different parts of the world;

GC1.04 – explain how satellites support global communication, navigation, surveying, imaging, and mapping.

Developing and Practising Skills

GC2.01 – interpret maps and images to learn about areas that cannot be experienced at first hand;

GC2.02 – compare images of different areas to identify similarities and contrasts;

GC2.03 – interpret satellite images to obtain a synoptic view of major world features (e.g., mountain systems, vegetation belts, oceans).

Learning Through Application

GC3.01 – explain how maps, especially maps of unfamiliar lands, can convey a misleadingly simple view of reality;

GC3.02 – explain the implications of the Eurocentric bias that results from centring conventional world maps on the Greenwich meridian;

GC3.03 – analyse the use of maps in propaganda, both negative propaganda intended to mislead and positive propaganda intended to benefit humanity;

GC3.04 – assess the positive and negative impacts of the use of geotechnologies in international affairs (e.g., GIS in disaster relief, GPS in military operations, satellites in monitoring of nuclear sites);

GC3.05 – examine the ethical aspects of the use of GIS, GPS, and related technologies, especially the implications for individual privacy, marginalized groups, and minority cultures.

Understanding and Managing Change

Overall Expectations

UCV.01 · explain the use of geotechnologies in monitoring change in dynamic systems;

UCV.02 · explain the use of geotechnologies in modelling and predicting future change;

UCV.03 · identify key stages in the evolution of geomatics.

Specific Expectations

Understanding Concepts

UC1.01 – explain the role of geotechnologies, especially satellite imaging, in monitoring changing phenomena (e.g., crop growth, clear-cutting, oil spills);

UC1.02 – show how modern geotechnologies can be used to measure changes that were formerly undetectable (e.g., monitoring crustal movements by GPS);

UC1.03 – identify the main advances in geomatics in the late twentieth century and describe current trends;

UC1.04 – identify key Canadian contributions to geomatics (e.g., Radarsat, Canada Geographic Information System);

UC1.05 – describe the extension of geomatics applications into non-traditional domains (e.g., criminology, marketing, medicine);
UC1.06 – identify present and future career opportunities in GIS, remote sensing, cartography, and surveying;
UC1.07 – describe the impact of continuous change on the user of geotechnologies (e.g., personal stress, increased cost, need for retraining).

Developing and Practising Skills
UC2.01 – predict changes in the weather by correctly interpreting meteorological charts;
UC2.02 – analyse the role of geotechnologies in predicting catastrophic events (e.g., hurricanes, avalanches, earthquakes);
UC2.03 – analyse the role of geotechnologies in anticipating long-term change (e.g., desertification, urban sprawl, rise in sea level).

Learning Through Application
UC3.01 – describe changes in their local landscape through time by interpreting a temporal sequence of maps or aerial photographs;
UC3.02 – model and predict future change in a physical or human system, using GIS (e.g., determining the effects of climatic change on crop growth).

Methods of Geographic Inquiry

Overall Expectations
GIV.01 · select and apply geographic skills, methods, and technologies to gather, analyse, and synthesize ideas and information;
GIV.02 · use a variety of methods and technologies to communicate the results of geographic inquiry and analysis effectively;
GIV.03 · evaluate sources of spatial and other data.

Specific Expectations
Understanding Concepts
GI1.01 – describe methods of acquiring raw data (e.g., direct measurement, questionnaire surveys, field observation);
GI1.02 – identify sources of data, maps, images, and other geographic products (e.g., governments, private companies, the Internet);
GI1.03 – identify the areal units by which data are commonly aggregated (e.g., enumeration areas, census tracts, school districts);
GI1.04 – explain the basic principles of, and the main techniques used in, surveying (e.g., use of tapes and compasses, measurement of distances and angles, use of GPS);
GI1.05 – explain the basic principle underlying GPS and the significance of differential GPS;
GI1.06 – explain the four basic mapping transformations: reduction, projection, generalization, and symbolization;
GI1.07 – demonstrate an understanding of the conceptual and artistic factors that make for a well-designed map or graphic (e.g., good generalization, symbol contrast, balanced layout);
GI1.08 – identify the sources and explain the characteristics of different types of electromagnetic radiation and their uses in remote sensing (e.g., using different kinds of infrared emissions to measure temperature and humidity in different parts of the atmosphere);
GI1.09 – classify remote sensing methods according to technology (e.g., photography, radar) and platform (e.g., airborne, spaceborne);
GI1.10 – explain the processes of aerial photography, remote sensing, thermography, and radar;

GI1.11 – explain the principles of image interpretation, with particular reference to aerial photographs;
GI1.12 – identify the main subsystems of a GIS (i.e., data input, data management, data analysis, data output);
GI1.13 – explain the concept of layering and the difference between the rastor and vector data models;
GI1.14 – describe the structure of a database and explain basic database functions, including querying;
GI1.15 – explain key analytical operations in GIS (e.g., reclassification, overlaying, buffering).

Developing and Practising Skills

GI2.01 – assess the quality of data in terms of factors such as accuracy, completeness, currency, and cost;
GI2.02 – convert analogue data to digital data for computer input (e.g., by scanning or digitizing);
GI2.03 – use the Internet effectively to access information relevant to geomatics;
GI2.04 – execute basic survey operations by pacing or with the aid of simple instruments;
GI2.05 – determine the locations and elevations of points, using a GPS receiver;
GI2.06 – orient a map or aerial photograph in the field and relate the features shown to the surrounding landscape;
GI2.07 – classify maps according to type (e.g., topographic, thematic, navigational);
GI2.08 – produce a variety of good quality maps, charts, and graphs, using computer software or other methods;
GI2.09 – perform basic operations correctly on topographic maps (e.g., specify location by six-figure reference; measure distances, using scales; read elevations from contours; identify symbols, using the legend);
GI2.10 – use a variety of visual representation techniques (e.g., graphics, relief models, computer displays) to depict the earth's surface in novel ways;
GI2.11 – interpret a variety of remote sensing images, from aerial photographs to satellite images;
GI2.12 – perform basic operations correctly on aerial photographs (e.g., determine scale by measurement, identify features by interpretation, view the landscape in 3D using a stereoscope);
GI2.13 – use GIS software appropriately to perform analytical operations (e.g., overlay analysis, route determination, database querying, simple image analysis).

Learning Through Application

GI3.01 – execute a systematic field survey in their local area and plot the results as a map;
GI3.02 – critically assess the results of a GIS analysis in the light of such factors as data quality, cell size, and initial assumptions;
GI3.03 – evaluate the use of GIS and other geotechnologies in comparison with alternative approaches used by geographers (e.g., field observation, library research, scientific experimentation).

Ontario Catholic School Graduate Expectations

The graduate is expected to be:

A Discerning Believer Formed in the Catholic Faith Community who

CGE1a -illustrates a basic understanding of the **saving story** of our Christian faith;

CGE1b -participates in the **sacramental life** of the church and demonstrates an understanding of the centrality of the Eucharist to our Catholic story;

CGE1c -actively reflects on **God's Word** as communicated through the Hebrew and Christian scriptures;

CGE1d -develops attitudes and values founded on Catholic **social teaching** and acts to promote social responsibility, human solidarity and the common good;

CGE1e -speaks the **language of life**... "recognizing that life is an unearned gift and that a person entrusted with life does not own it but that one is called to protect and cherish it." (Witnesses to Faith)

CGE1f -seeks intimacy with God and celebrates **communion** with God, others and creation through prayer and worship;

CGE1g -understands that one's purpose or **call in life** comes from God and strives to discern and live out this call throughout life's journey;

CGE1h -respects the **faith traditions**, world religions and the life-journeys **of all people of good will**;

CGE1i -integrates faith with life;

CGE1j -recognizes that "sin, human weakness, conflict and forgiveness are part of the human journey" and that the cross, the ultimate sign of forgiveness is at the heart of **redemption**. (Witnesses to Faith)

An Effective Communicator who

CGE2a -listens actively and critically to understand and learn in light of gospel values;

CGE2b -reads, understands and uses written materials effectively;

CGE2c -presents information and ideas clearly and honestly and with sensitivity to others;

CGE2d -writes and speaks fluently one or both of Canada's official languages;

CGE2e -uses and integrates the Catholic faith tradition, in the critical analysis of the arts, media, technology and information systems to enhance the quality of life.

A Reflective and Creative Thinker who

CGE3a -recognizes there is more grace in our world than sin and that hope is essential in facing all challenges;

CGE3b -creates, adapts, evaluates new ideas in light of the common good;

CGE3c -thinks reflectively and creatively to evaluate situations and solve problems;

CGE3d -makes decisions in light of gospel values with an informed moral conscience;

CGE3e -adopts a holistic approach to life by integrating learning from various subject areas and experience;

CGE3f -examines, evaluates and applies knowledge of interdependent systems (physical, political, ethical, socio-economic and ecological) for the development of a just and compassionate society.

A Self-Directed, Responsible, Life Long Learner who

CGE4a -demonstrates a confident and positive sense of self and respect for the dignity and welfare of others;
CGE4b -demonstrates flexibility and adaptability;
CGE4c -takes initiative and demonstrates Christian leadership;
CGE4d -responds to, manages and constructively influences change in a discerning manner;
CGE4e -sets appropriate goals and priorities in school, work and personal life;
CGE4f -applies effective communication, decision-making, problem-solving, time and resource management skills;
CGE4g -examines and reflects on one's personal values, abilities and aspirations influencing life's choices and opportunities;
CGE4h -participates in leisure and fitness activities for a balanced and healthy lifestyle.

A Collaborative Contributor who

CGE5a -works effectively as an interdependent team member;
CGE5b -thinks critically about the meaning and purpose of work;
CGE5c -develops one's God-given potential and makes a meaningful contribution to society;
CGE5d -finds meaning, dignity, fulfillment and vocation in work which contributes to the common good;
CGE5e -respects the rights, responsibilities and contributions of self and others;
CGE5f -exercises Christian leadership in the achievement of individual and group goals;
CGE5g -achieves excellence, originality, and integrity in one's own work and supports these qualities in the work of others;
CGE5h -applies skills for employability, self-employment and entrepreneurship relative to Christian vocation.

A Caring Family Member who

CGE6a -relates to family members in a loving, compassionate and respectful manner;
CGE6b -recognizes human intimacy and sexuality as God given gifts, to be used as the creator intended;
CGE6c -values and honours the important role of the family in society;
CGE6d -values and nurtures opportunities for family prayer;
CGE6e -ministers to the family, school, parish, and wider community through service.

A Responsible Citizen who

CGE7a -acts morally and legally as a person formed in Catholic traditions;
CGE7b -accepts accountability for one's own actions;
CGE7c -seeks and grants forgiveness;
CGE7d -promotes the sacredness of life;
CGE7e -witnesses Catholic social teaching by promoting equality, democracy, and solidarity for a just, peaceful and compassionate society;
CGE7f -respects and affirms the diversity and interdependence of the world's peoples and cultures;
CGE7g -respects and understands the history, cultural heritage and pluralism of today's contemporary society;
CGE7h -exercises the rights and responsibilities of Canadian citizenship;
CGE7i -respects the environment and uses resources wisely;
CGE7j -contributes to the common good.

Unit 1: The Fundamentals of Geomatics

Time: 20 hours

Unit Description

In this unit, students explore the structure and concepts used to construct both traditional maps and maps made with a GIS. Students gain an overall understanding of the history of map-making and the tools and techniques used for geographic analysis. Even though students use technology in map-making, the basic underlying principle is that the features on maps represent the natural phenomena on earth, thus reinforcing the Catholic social teaching of the sanctity of life. This unit should include a basic understanding of map projections and how manipulating map projections can alter our perception of the world. Students are introduced to the primary functional concepts of a GIS – map-making, using a variety of themes, ordering layers, using text annotations, and performing the layout of a map. Included with the understanding of a GIS is the introduction to complementary computer programs, such as spreadsheets, drawing software, and graphic packages, that are used in combination to produce well-designed and functional maps.

Strand(s): Geographic Foundations: Space and Systems, Human-Environment Interactions, Global Connections, Understanding and Managing Change, Methods of Geographic Inquiry

Unit Synopsis Chart

Activity	Learning Expectations	Assessment Categories	Focus
1.1 Introduction to Geomatics	SSV.01, HEV.02, GCV.01, GC1.01, GI2.07 CGE1d, 7b	Knowledge/ Understanding Thinking/Inquiry	Students contemplate the integration of geography in their daily lives and are introduced to geotechnology.
1.2 History of Map-making	UCV.03, UC1.03, GC1.03, GC3.02, SS1.02, SS2.04, SS3.01 CGE2c, 3c, 3e	Knowledge/ Understanding Thinking/Inquiry	Students study the development of maps and their influence on events.
1.3 The Purpose of Map-Making	GCV.03, GI1.06, SSV.03, SS1.03, SS1.07, SS1.08 CGE1d, 3b	Application Communication	Students construct maps using components, such as projections, to convince others of a point of view.
1.4 Introduction to GIS – Components of GIS and Their Uses	SSV.02, GCV.02, GI1.12, GI1.14, GC3.03, GIV.03, SS2.01 CGE1d, 1i, 2e, 3f, 5a	Knowledge/ Understanding Thinking/Inquiry	Students become familiar with the uses of and skills associated with a GIS.
1.5 Georeferencing Images for Use in a GIS	GIV.03, GI2.02, SS2.01 CGE1i, 3f, 5g	Knowledge/ Understanding Application	Students develop their GIS information-management skills and geotechnical analysis skills.
1.6 Constructing a World Map with Layers	SSV.04, GC3.04 CGE3b, 3c, 3d, 7b	Application	Students add layers to a world map and analyse the patterns.

Activity	Learning Expectations	Assessment Categories	Focus
1.7 Culminating Activity – Making a World Map Layout for Other Applications	GI1.07, GI2.10, GCV.01 CGE1d, 2a, 2b, 3c, 3f	Application Communication	Students create a world map for use in a geographic analysis.

Culminating Activity

The focus of the culminating activity is the creation of a world map that is used in the geographic analysis of a specific issue. Students use basic geotechnical skills to measure both attribute and spatial parameters, i.e., this may include the location of specific places using latitude/longitude or UTM coordinates and/or analysis of the socio-demographic statistics to the specific places, present their findings in a properly constructed layout, and, from this map, make conclusions in light of the biblical concept of stewardship. Students should present their findings using a variety of map projections and analysis of how these projections influence the message of the map. Examples include mapping and analysing such issues as economic indicators or natural disaster identification. Students evaluate their ideas in light of the common good.

Activity 1.1: Introduction to Geomatics

Time: 2.5 hours

Description

In this activity, the teacher reviews with students how geography is constantly integrated into our daily lives. Students are introduced to supporting geotechnological programs, such as presentation software, e.g., *PowerPoint,* or drawing software, e.g., *CorelDraw*, which are used to display information. Students, in small groups, create graphic displays of "How Geography Affects the Lives of Human Beings." Through the study of geography in daily activities, such as saving lives, fighting crime, and responding to natural disasters, students appreciate the Catholic social teaching of promoting social responsibility.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE2b - read, understand, and use written materials effectively;
CGE1d - develop attitudes and values founded on Catholic social teaching and act to promote social responsibility, human solidarity, and the common good;
CGE7b - accept accountability for one's own actions.

Strand(s): Geographic Foundations, Methods of Geographic Inquiry

Overall Expectations

SSV.01 - explain how the earth is modelled for scientific and mapping purposes;
GCV.01 - explain the use of geotechnologies in addressing issues of global concern;
HEV.02 - evaluate the effectiveness of geotechnologies in identifying environmental problems and finding solutions.

Specific Expectations

GI2.07 - classify maps according to type (e.g., topographic, thematic, navigational);
GC1.01 - explain the role of geotechnologies in addressing issues affecting the world as a whole (e.g., global warming, overpopulation, warfare).

Prior Knowledge & Skills

- Basic understanding of GIS and geotechnologies
- Knowledge of how to log on to computer networks and use presentation/graphics software, such as *MS PowerPoint, MS Paint,* and *CorelDraw*
- Presentation skills

Planning Notes

- Prepare a hardcopy of the slideshow for students.
- Remind students of the school board policy with respect to computers and use of the Internet.
- Have appropriate clipart or websites available to aid students in their presentations.
- Photocopy the document "Geography Matters" (OAGEE) for each student (see Resources).

Teaching/Learning Strategies

1. The teacher directs a short electronic slideshow presentation and discussion on the components of geography, concluding with the role of technology in geography. The teacher reviews techniques for using the software to create an effective presentation. The teacher hands out copies of the ESRI White Paper "Geography Matters" to students.
2. In small groups, students work on an electronic slideshow presentation based on topics found in "Geography Matters."
3. Students present their slideshows to the class. Presentations are assessed by self, peers, and the teacher.
4. The teacher directs a discussion on the definition of Geomatics and how it is used today in Canada.

Assessment & Evaluation of Student Achievement

The final product can be assessed by the teacher or by students. Teachers must assess where the result will contribute to the final mark. In many instances, peer evaluation is effective as it allows students to showcase their work. The teacher ensures that the rubric is prescriptive and detailed so that the assessor is not distracted by colourful images that show little geographic reasoning,

T/L Strategy Number	Task/Product	Tool	Purpose	Achievement Categories
1	Whole-class discussion	Teacher-centred presentation	Formative	Knowledge/Understanding Thinking/Inquiry Communication
2	Creation of group presentation on how geography influences humans	Computer software	Formative	Thinking/Inquiry Application Communication
3	Student presentation on work completed	Student-centred presentation and evaluation	Summative	Thinking/Inquiry Application Communication
4	Whole-class discussion	Teacher-centred presentation	Formative	Thinking/Inquiry Application Communication

Accommodations

- Electronic presentation could be printed as notes for students.
- ESL students and exceptional students may require specific help with key terms and concepts.
- For enrichment, students research professionals/businesses in the local area who use GIS. Students present their findings to the class.

Resources

Print

"Geography Matters," *Geokit* (CD). OAGEE, 1999. Also available at – www.esricanada.com.

Websites

The Champlain Institute – http://www.champins.ns.ca/geomatics.html

Geomatics Industry Association of Canada – http://www.giac.ca/site/geomatics/geomatics.html

Team Canada: Geomatics – http://www.geocan.nrcan.gc.ca/geomatics/htmle/gen-g01.html

Software

Microsoft *PowerPoint* or other presentation software

Activity 1.2: History of Map-Making

Time: 3.75 hours

Description

Students work creatively to evaluate situations and solve problems by drawing a map based on a paragraph description and creating a scaled drawing of the map in a drawing program. Students learn and identify map types and projection along with the history of cartography.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE2c - present information and ideas clearly and honestly and with sensitivity to others;
CGE3c - think reflectively and creatively to evaluate situations and solve problems;
CGE3e - adopt a holistic approach to life by integrating learning from various subject areas and experience.

Strand(s): Space and Systems, Human-Environment Interactions, Methods of Geographic Inquiry, Understanding and Managing Change

Overall Expectations

UCV.03 - identify key stages in the evolution of Geomatics.

Specific Expectations

UC1.03 - identify the main advances in geomatics in the late twentieth century and describe current trends;
SS1.02 - explain the concepts of reference ellipsoid, reference sphere, and datum;
SS2.04 - classify map projections as azimuthal, conical, or cylindrical based on the appearance of the meridians and parallels;
SS3.01 - describe the properties and uses of important map projections, especially those commonly used in Canada (e.g., the Transverse Mercator and the Lambert Conformal);
GC1.03 - explain how map projection distortions can misrepresent the relative areas of different parts of the world;
GC3.02 - explain the implications of the Eurocentric bias that results from centring conventional world maps on the Greenwich meridian.

Prior Knowledge & Skills

- Electronic presentation skills learned in Activity 1.1
- Basic understanding of the cartographic conventions of maps, e.g., title, scale, compass, legend, etc.

Planning Notes

- Obtain a blank floor plan of the school.
- Collect tape measures or metre-stick rulers.
- Prepare a lesson on the history of maps and components of maps.
- Have blank paper available for mental maps.
- Remind students to obtain different types of maps from various print sources and bring them to class.

Teaching/Learning Strategies

1. Students show their maps, which they collected as homework after the previous lesson, to the class. While students identify the types of maps, the teacher groups the maps into Thematic, Topographic, and General Purpose and labels them accordingly.
2. Students write a paragraph describing the route from their house to a relative's house. The paragraph is then given to another student who is asked to draw the route. The teacher discusses map findings with the class, emphasizing the need to include direction, landmarks, and scale. Maps can be self-evaluated or peer evaluated.
3. The teacher facilitates a lesson on maps, using an electronic presentation or through the more traditional method of overheads. The discussion includes the topics: A Definition of a Map; Parts of a Map; Map Uses; The History of Map-Making; Map Scale and Types of Scale; Changing Scales; Longitude and Latitude; Compass Directions; and Map Projections; and Key Stages in the Evolution of Geomatics.
4. In small groups, students complete a scaled map of a section of the school. The results of their scaled findings are drawn using software, such as *CorelDraw* or *ArcView*. The teacher reminds students to set an appropriate scale for their drawing and to include cartographic conventions of mapping. Map assignments are submitted for evaluation.

Assessment & Evaluation of Student Achievement

The teacher ensures that all map elements are present and that the student has made good use of geographic terminology and of the techniques learned so far. Students need to have time to evaluate their peers' accomplishments. The goal is to have students create better maps overall. The teacher should carefully direct peer and self-evaluation. Teachers will assess where results contribute to the final mark.

T/L Strategy Number	Task/Product	Tool	Purpose	Achievement Categories
1	Teacher-guided lesson on types of maps	Discussion	Formative	Knowledge/ Understanding
2	Individual mental map construction	Worksheet	Formative	Application
3	Teacher-guided lesson on parts of a map	Teacher-generated overheads/worksheets	Formative	Knowledge/ Understanding
4	Small-group and individual cartographic assignment (creation of school map)	Worksheet	Summative	Thinking/Inquiry Application

Accommodations

- Provide flexible timelines for completion of the map assignment.
- Adapt the requirements for the summative assignment at the end of the activity.

Enrichment

- Students could further study early map-makers and present their findings to the class.

Resources

Paper
Overheads and blackline masters of the school
Overhead of Canada

Software
Microsoft *PowerPoint* or other presentation software

Print
Mitchell, Andy. *The ESRI Guide to GIS Analysis: Volume 1: Geographic Patterns & Relationships*. ESRI Press. ISBN 1-879102-06-4

Activity 1.3: The Purpose of Map-Making

Time: 1.25 hours

Description

This activity helps students appreciate how maps made with different projections persuade a cartographer's point of view. Students understand that certain projections perform different functions. One projection, for example, might well be suited for navigation charts because of the true compass bearings, another may be liked by mapping organizations because of the balance between size, shape, direction and distance and some cause distortion of the countries/sizes. Students develop attitudes and values founded on Catholic teaching while promoting social responsibility, human solidarity, and the common good. The Peters Projection is examined. Many issues of social justice are considered using this projection.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations
CGE1d - develop attitudes and values founded on Catholic social teaching and act to promote social responsibility, human solidarity, and the common good;
CGE3b - create, adapt, and evaluate new ideas in the light of the common good.

Strand(s): Geographic Foundations, Methods of Geographic Inquiry, Human-Environment Interactions, Global Connections

Overall Expectations
SSV.03 - explain the process of map projection and the properties and uses of selected projections;
GCV.03 - analyse how perceptions of places, situations, and events are affected by maps.

Specific Expectations
SS1.03 - define great circles, small circles, meridians, and parallels and explain the concept of great circle distance;
SS1.07 - differentiate between spatial and non-spatial data; point, line, and area data; and qualitative and quantitative data;
SS1.08 - explain how map projections are used to transform the curved surface of the earth into a flat map, using examples from four broad groups of projections: azimuthal, conical, cylindrical, and miscellaneous;
GI1.06 - explain the four basic mapping transformations: reduction, projection, generalization, and symbolization.

Prior Knowledge & Skills

- Skills learned in previous lessons, such as cartographic conventions and map-making
- Internet search skills

Planning Notes

- Prepare a handout for students to follow during a brief review of the parts of a map; include scale, longitude, latitude, and direction.
- Create an Internet-based assignment which allows students to research information on map projections and great circles. This assignment should have students research at least four types of map projections, the definition of a great circle, and a question to make them understand the concept of the great circle. The teacher provides students with available websites (see Resources).

Teaching/Learning Strategies

1. The teacher reviews the parts of a map along with cartographic conventions.
2. Students search the Internet for types of map projections and great circles. Students research at least four types of map projections, the definition of a great circle, and a question that requires calculation of a great circle from the closest city with an international airport to London, England. Students fill in a handout and hand it in to be corrected (see Appendix 1.3.1 – Internet-Based Assignment on Map Projections and Great Circles).
3. Students research an example of each type of map projection from the Internet and include at least two reasons why the type of projection is appropriate for the information. These maps, along with the reasons, should be pasted onto Bristol board and displayed in the classroom or presented in and electronic presentation. Through class discussion, students become aware of the best types of projection for each map.

Assessment & Evaluation of Student Achievement

T/L Strategy Number	Task/Product	Tool	Purpose	Achievement Categories
1	Teacher-guided lesson to review parts of map	Question/answer and discussion	Formative	Knowledge/ Understanding
2	Answers to teacher-generated worksheet on map projections and great circles	Teacher-generated worksheet	Formative	Knowledge/ Understanding Thinking/Inquiry
3	Student-generated display board on map projections	Internet search for information	Summative	Application Thinking/Inquiry

Accommodations

- Where required, provide a flexible timeline for completion of the display board.
- For enrichment, students produce a variety of maps used for various industries, e.g., the type of map an airline company uses, the type of map the United Nations might use for displaying global data, etc.

Resources

Websites

Airport City Codes – http://www.airportcitycodes.com/aaa/CCDBFrame.html

The Geographer's Craft Map Projection Overview – http://www.Colorado.EDU/geography/gcraft/notes/mapproj

Great Circle Calculator – http://www.vwlowen.demon.co.uk/java/circle.htm

Great Circle Mapper – http://gc.kls2.com/

Great Circle Mapper FAQ – http://gc.kls2.com/faq.html

Maps.Com – http://www.maps.com/learn/101-content/skl-circles.html

Online Map Creation – http://www.aquarius.geomar.de/omc/omc_project.html

Software
Microsoft Explorer or *Netscape Communicator*
Microsoft *PowerPoint* or other presentation software

Appendix 1.3.1

Internet-Based Assignment on Map Projections and Great Circles

1. Identify four types of projections. In your directory, save an example of each projection type for later in the class.

2. What is the definition of a great circle?

3. Calculate the distance between Toronto, Ontario and London, England using a great circle. Then calculate the distance between the two cities using a map. What is the difference in distance? Create a map of the great circle and print it. Draw in the straight-line distance. Why is it better to go the great-circle route over the straight-line route?

Activity 1.4: Introduction to GIS – Components of GIS and Their Uses

Time: 3.75 hours

Description

Students learn the uses of and skills associated with a Geographic Information System (GIS). The acquisition of these skills allows students to use a GIS to develop attitudes and values found in Catholic social teachings and act to promote social responsibility and the development of a just and compassionate society. In a complete lab setting, students become familiar with major GIS software programs, such as *Arcview* or *MFTeach*. Students are introduced to the key concepts and uses of a GIS; the teacher guides students through the main features of the GIS program. In a number of activities, students learn how to locate programs, files, and shapefiles; identify the main subsystems of a GIS; and save their maps as JPEG files. Students learn powerful functions of a GIS, such as querying and creating map layouts.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE1d - develop attitudes and values founded on Catholic social teaching and act to promote social responsibility, human solidarity, and the common good;
CGE1i - integrate faith with life;
CGE3f - examine, evaluate, and apply knowledge of interdependent systems (physical, political, ethical, socio-economic, and ecological) for the development of a just and compassionate society;
CGE5a - work effectively as an interdependent team member;
GCE2e - use and integrate the Catholic faith tradition, in the critical analysis of the arts, media, technology, and information systems, to enhance the quality of life.

Strand(s): Geographic Foundations: Space and Systems, Global Connections, Methods of Geographic Inquiry

Overall Expectations

SSV.02 - demonstrate an understanding of basic spatial concepts;
GCV.02 - explain the use of geotechnologies in understanding peoples and places around the world;
GIV.03 - evaluate sources of spatial data.

Specific Expectations

GI1.12 - identify the main subsystems of a GIS (i.e., data input, data management, data analysis, data output);
GI1.14 - describe the structure of a database and explain basic database functions, including querying;
GC3.03 - analyse the use of maps in propaganda, both negative propaganda intended to mislead and positive propaganda intended to benefit humanity;
SS2.01 - express location correctly by geographic coordinates, grid coordinates, and other methods.

Prior Knowledge & Skills

- Experience with *ArcVoyager* and activities utilised in Grade 9 Geography of Canada
- Understanding of main operations of *ArcView* GIS, including the JPEG (JIFF) Image Support
- Experience working in small groups in a computer lab setting
- Experience navigating the school's computer network to locate programs and data files
- Experience with computer projection units
- Understanding of the principles of map projection
- Understanding of *ArcView* extension for exporting layouts as JPEG files
- Experience with the *ArcView* School Tools' extension (see Resources)

Planning Notes

- Prepare a GIS information presentation using *ArcVoyager*'s introductory material, "Exploring Key Concepts – Teach Me". Alternative materials for introducing key concepts can be obtained from ESRI Canada's website, the *GeoKit* CD, the *Geographer's Workbench* CD, or the *ArcView Geography Student Workbook and Teacher's Guide* (see Resources). Several of these sources include prepared *PowerPoint* presentations.
- Prepare an introductory worksheet on "How GIS Touches Our Everyday Life". A web map outline is available in Unit 1, Lesson 1.1 of *Geographer's Workbench* (see Resources).
- Copy appropriate K-12 Quick Start project and data files from *ArcCanada*, Disk 2 (found in ArcCanada2/lessons/k12 quick) to server.
- Locate and test data for each activity before use.
- Download introductory material and worksheets for the K-12 Quick Start project (Adobe PDF format). Prepare class sets of the worksheets.
- For evaluation purposes, the teacher decides, in advance, whether to have students print out their hard copy maps or save to their student directory.
- Completed map layouts can be saved as a JPEG file by using the JPEG (JIFF) Image Support extension; (*ArcView* includes extensions that support TIFF and other image files, if the teacher prefers to use these file formats). As well as taking up less space on the server, students can insert the JPEG files into a word-processed document or electronic slide show and then add written explanations and analyses directly to their completed map layouts.
- The teacher develops a set of questions/guidelines to assist students in their written report. The questions prompt students to use higher-order thinking skills to explain and describe the geographical information they acquired and the database functions that they used. Questions examine, evaluate, and apply knowledge of interdependent systems for the development of a just and compassionate society.
- The teacher may download the School Tools extension (see Resources) and load it into the *ArcView* program on the server or on stand-alone computers running the program.

Teaching/Learning Strategies

1. The teacher directs a short *ArcVoyager* presentation and a discussion on the main features and uses of a Geographic Information System. Students brainstorm ideas on how GIS can affect their everyday lives. Students complete a worksheet.
2. Students work two to a computer. Using a computer projector unit, the teacher demonstrates how to locate and load the *ArcView* program and where to locate the project and data files. The project GUI, menus, and buttons are introduced and the main tools are demonstrated. Copies of ESRI's *ArcCanada* – Quick Start worksheets are distributed to students. Students follow as the teacher guides them through the initial Quick Start activity, 'Getting To Know *ArcView*'. Students learn how to open files and use the Zoom, Pan, Identify, and Label tools. The teacher visits each pair and assesses how well students are developing their skills, using a checklist (Appendix 1.4.1 – Observation Checklist).
3. Students apply their newly-acquired GIS skills to the second activity in Quick Start, 'Out Of Africa'. Students produce a finished map in Layout, showing life expectancy as the main theme. Students complete the layout with the correct cartographic conventions and either print it out or save it to their student directory. The teacher guides students through relevant aspects of file management, such as saving work and adding additional data from a data drive. A marking scheme is used to evaluate the work (see Appendix 1.4.2 – Generic GIS Mapping Marking Scheme).

4. Students further develop their basic GIS skills by creating a thematic map of earthquakes in Canada. Students work individually at their own computers to increase their independent skills and knowledge. They are required to change the map projection of Canada. The teacher reviews the principles of map projection. Students try out various projections for Canada; the teacher leads a discussion on how the perception of a place can be improved or distorted depending on the type of projection used. Students continue with the ESRI activity and perform queries to ascertain the cities in Canada that are at most risk from a major earthquake. The teacher moves through the class, advising and asking pertinent questions to encourage higher-order thinking skills. The finished map is evaluated (see Appendix 1.4.3 – Earthquakes in Canada Marking Scheme).
5. Using the data presented in their completed maps, students write a report on the information presented in their two map layouts (Life Expectancy In Africa and Earthquakes in Canada). Students explain how the use of various GIS functions helped in the presenting and analysing of the data. Students save their work as JPEG files. Students create a report, as either a word-processed document or an electronic slide show, and insert the JPEG files into it. The report is evaluated using a teacher-developed rubric.

Assessment & Evaluation of Student Achievement

Assessment of students should focus on the development of critical-thinking skills. These initial lessons require reinforcement and guided learning. Repetition of skills occurs throughout the course and teachers should be aware that it takes some students longer than others to become proficient. There is a tendency to evaluate the first maps with high marks, as they can appear very professional. However, care should be taken to ensure that all map elements are present and that the student has made good use of geographic terminology and of the techniques learned so far. Students need to have time to evaluate their peers' accomplishments. The goal is to have students create better maps overall. The teacher should carefully direct peer and self-evaluation.

T/L Strategy Number	Task/Product	Tool	Purpose	Achievement Categories
1	Understanding GIS presentation	Worksheet/web map	Formative	Knowledge/ Understanding
2	Introduction to main *ArcView* skills and tools	Anecdotal notes Observation checklist	Informal	Application
3	Development of map layout (in pairs)	GIS map marking scheme	Formative	Communication Application
4	Production of individual thematic maps	GIS map marking scheme	Formative	Communication Application
5	Concluding written report	Paragraph checklist Teacher-developed rubric	Formative	Knowledge/ Understanding Communication Application

Accommodations

- Provide individual support in GIS projects.
- When required, provide extended time on the computer to finish work and allow students to work with partners.
- Provide a flexible timeline for completion of the maps.
- A review of presentation software structure may be necessary for some students with writing difficulty. An exemplar presentation or template may be beneficial.

- As an extension to the study of map projection and how maps can be produced to inform or mislead, teachers may use the lesson package "Projection Propaganda," available at the ESRI Canada website. As extension to the mapping of language and propaganda themes, "Everything you wanted to know about lying with maps" is a package available in the *ArcView Geography Student Workbook and Teacher's Guide* (see Resources).

Resources

Print

Audet, Richard and Gail Ludwig. *GPS in Schools*. New York: ESRI Press, 2000.

ESRI. *Getting To GIS*. New York: ESRI Press, 1998. ISBN 1879102463

Kennedy, H., ed. *Dictionary of GIS Terminology*. New York: ESRI Press, 2001.

Mitchell, Andy. *The ESRI Guide to GIS Analysis*. New York: ESRI Press, 2000.

Nicolucci, John and Rex Taylor. *ArcView Geography Student Workbook and Teacher's Guide*. Toronto: Crescent School, 1999.

Software

ESRI. *Arcview 3.X.* ESRI Canada. Obtainable through Board OESS rep.

ERSI Canada. *ArcVoyager Special Edition* (included with *ArcView* software).

Data

ESRI Canada. *ArcCanada v.2.0*, Disc 2 – K-12 Quick Start project. Toronto: ESRI Canada Schools and Libraries Program, 1999.

Websites

– http://www.esricanada.com/k-12/index.html
ArcView lesson packages, teacher tutorials, and *PowerPoint* presentations

– http://www.esricanada.com/k-12/schooltools/schtools2.html
ArcView 'Schools Tools' extension (this software is free to download

Appendix 1.4.1

Observation Checklist – Learning Skills

Student Name:

Observed by:

Criteria	Dates Observed					
The workspace is organized.						
The student remains focused on task.						
Discussions with peers are relevant to the task.						
The student assembles the required tools (books, pens, etc.).						
The student follows directions.						
The student asks relevant questions.						
The student uses appropriate voice level.						
The student starts task without prompting.						
The student shows tolerance for others' ideas.						
The student is alert in class.						
The student participates in small-group discussions.						
The student participates in large-group discussions.						
The student expresses his/her ideas and opinions.						
The student is polite to peers and adults.						

General Comments:

Appendix 1.4.2

Generic GIS Mapping Marking Scheme

Name:

Project:

TITLE	Correct and present	/1
	Printed neatly	/1
	Positioned in appropriate position	/1
LEGEND	Positioned in appropriate area	/1
	Correctly constructed	/1
LABEL	Aligned correctly	/1
	Spelled accurately	/1
LAYOUT	Appropriate font size and clarity	/2
	Appropriate use of colour/graduation	/2
	Border present	/1
	Scale bar present	/1
	North arrow present	/1
	Overall proportionality	/4
OVERALL ACHIEVEMENT LEVEL	**Mark**	**/20**

Comments:

Appendix 1.4.3

Earthquakes in Canada Marking Scheme

Name:

TITLE	Correct and present	/1
	Printed neatly	/1
	Positioned in appropriate position	/1
LEGEND	Positioned in appropriate area	/1
	Correctly constructed	/1
LAYOUT	Correct projection used	/1
	Earthquakes shown and earthquakes over 4.0 magnitude identified	/4
	Graduated colours applied to population	/2
	Cities falling within 350km of 4.0 magnitude earthquake identified	/2
	Appropriate font size and clarity	/2
	Appropriate use of colour/graduation	/2
	Border present	/1
	Scale bar present	/1
	North arrow present	/1
	Overall proportionality	/4
OVERALL ACHIEVEMENT LEVEL	**Mark**	**/25**

Comments:

Activity 1.5: Georeferencing Images for Use in a GIS

Time: 1.25 hours

Description

Students use a GIS to register a digital image. Students acquire experience in using various GIS functions and the *ArcView* School Tools and Register extensions to 'register' an image for use with other GIS data. The use of images with other GIS themes allows students to witness the miracle of earth's systems functioning and working together, reinforcing the concept of interdependence and mutuality. By registering an image, the GIS program georeferences its location in the world; students learn that the registered image can be a useful source of supporting data. The teacher scans a hard-copy map, aerial photograph, or satellite image and saves it as digital image. Students, however, use the GIS to register the image as a map 'theme'. Once this is done, students locate and open other related layers/themes to overlay on the registered image. As a final product, students create a layout and a brief written report of the results of their findings.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE1i - integrate faith with life;
CGE3f - examine, evaluate, and apply knowledge of interdependent systems (physical, political, ethical, socio-economic, and ecological) for the development of a just and compassionate society;
CGE5g - achieve excellence, originality, and integrity in one's own work and support these qualities in the work of others.

Strand(s): Methods of Geographic Inquiry

Overall Expectations

GIV.03 - evaluate sources of spatial and other data.

Specific Expectations

GI2.02 - convert analogue data to digital data for computer (e.g., by scanning or digitising).

Prior Knowledge & Skills

- Experience with *ArcView* program and Schools Tools and Register extensions
- Understanding of main operational skills involved with *ArcView* GIS and extensions
- Experience in downloading programs and images from the Internet
- Experience in navigating the school's computer network to locate programs and data files
- Experience with computer projection units
- Knowledge of scanning and saving maps, aerial photographs, etc. as digital images (JPEG, TIFF, etc.)

Planning Notes

- While registering an image can be done using a GIS program, such as *ArcView* or *MFTeach*, use the School Tools and Register extensions to simplify the tasks and time required (see Resources).
- Download and copy the extensions from the ESRI Canada website. Technical Note: when the Register extension file has been downloaded, paste it in the Ext32 folder in the *ArcView* program folder.
- Locate the added extensions in the *ArcView* program and test extensions before use.

- Scan a hard copy or download an image from the Internet to be registered. Examples include satellite images of Canada or the world, aerial photographs, and topographic maps of the local area. Make sure that all images that are scanned or downloaded from the Internet have copyright clearance.
- **Technical Note:** with larger-scale images, the teacher should make sure that the projection of the scanned images matches the projection of the data sets that are to be overlaid.
- Copy appropriate data files from *ArcCanada 2.0*, Disk 1, to school's data drive.
- For evaluation purposes, the teacher decides, in advance, whether to have the students print out their hard copy maps or save them to a personal directory for evaluation/assessment at a later time.
- Work can be saved as a JPEG file by using the JPEG (JIFF) Image Support.
- The teacher develops and prints out a set of questions/guidelines to assist students in their reports. Questions prompt students to use higher-order thinking skills.
- The teacher may load the School Tools extension into the *ArcView* program on the server or to stand-alone computers running the program.
- As an extension, students may work through the more comprehensive 'Working With Images' lesson in the *ArcView Geography Student Workbook and Teacher's Guide* (see Resources).
- GPS activities can make use of scanned images of local topographic maps and/or aerial photographs. This would be useful if the '10 by 10 Box of local data' (see Resources) is available.

Teaching/Learning Strategies

1. Using a computer overhead projector, the teacher reintroduces the *ArcView* program and guides students in locating and opening the program. The teacher explains that this activity requires the use of extensions to the regular program. Students open a New Project and the teacher guides them in locating and turning on the appropriate image support extension (e.g., JPEG (JFIF) Image Support). Students also turn on the K-12 School Tools V2 extension and the Image to World File Image Creator extension. Students check to see that a blue diamond icon has appeared on the Project Window (this confirms that the Image to World File Image Creator is in operation). Students click on the icon.
2. Students use the teacher-prepared worksheet to locate the image file. Students locate the Image to be Rectified (the JPEG image produced by the teacher) and the Registration Map (the theme that is used to register the image). Students click on the Ground Control Point (GCP) button and mark on matching GCPs on the two views. Students, following the worksheet, calculate the RMS and create a World File. By creating a World File, the student has registered the image and the GIS recognizes its location.
3. Under File, students choose New Project and turn on the appropriate image support extension. The registered image is located and added as a theme. The teacher instructs students on the files that are to be added as themes to overlay the image. Students locate and add these themes. Students complete a map Layout with the correct cartographic notation and either print it out or save it in their personal directory. The completed project is saved as a JPEG file and inserted into a written report. The layout is marked using an appropriate GIS map rubric. Using the data presented in their completed map, students write a report on the information they have produced. Students explain how the use of various GIS functions helped in presenting and analysing the data. The report is evaluated by the teacher using an appropriate tool such as a teacher-designed rubric, which uses criteria specific to this task.

Assessment & Evaluation of Student Achievement

T/L Strategy Number	Task/Product	Tool	Purpose	Achievement Categories
1	Introduction to *ArcView* extensions	Observation checklist	Formative	Knowledge/ Understanding Application
2	Registering of image activity (individual)	Observation checklist	Formative	Application
3	Production of new project using the registered image Concluding written report (individual)	GIS map rubric Teacher-designed rubric	Formative Summative	Application Knowledge/ Understanding Application Communication

Accommodations

- Provide extended time on the computer to finish work and allow students to work with partners.
- ESL students and students some exceptional students may require specific help with key terms and concepts found in the articles.

Resources

Software

ESRI. *Arcview 3.X.* ESRI Canada. Obtainable through Board OESS rep.

Data

ESRI Canada. *ArcCanada v.2.0*. Toronto: ESRI Canada Schools and Libraries Program, 1999.

ESRI Canada. *The 10 by 10 box of local data set for school*. Toronto: ESRI Canada Schools and Libraries program, 2001.

Nicolucci John and Rex Taylor. *ArcView Geography Student Workbook and Teacher's Guide*. Toronto: Crescent School, 1999.

Print

ESRI. *Getting To GIS*. New York: ESRI Press, 1998. ISBN 1879102463

Kennedy, H., ed. *Dictionary of GIS Terminology*. New York: ESRI Press, 2001. ISBN 1879102781

Mitchell, Andy. *The ESRI Guide to GIS Analysis*. New York: ESRI Press, 2000. ISBN 187910206

Websites

ESRI Canada – www.esricanada.com/k-12 (*ArcView* teacher tutorials and *PowerPoint* presentations) – www.esricanada.com/k-12/schooltools/schtools2.html (*ArcView* Schools Tools and Register extensions)

Activity 1.6: Constructing a World Map with Layers

Time: 3.75 hours

Description

This activity acquaints students with the use and operation of a geographic information system (GIS). On top of an image of the world at night, students add a series of layers or themes to a map and analyse the patterns associated with these layers. This activity introduces students to many of the operational tools associated with a GIS, such as file management, legend editing, zooming, labelling, and editing. During the activity, students appreciate how a GIS is a useful geotechnical tool in analysing and problem solving in light of gospel teachings.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE3b - create, adapt, and evaluate new ideas in light of the common good;
CGE3c - think reflectively and creatively to evaluate situations and solve problems;
CGE3d - make decisions in the light of gospel values with an informed moral conscience;
CGE7b - accept accountability for one's own actions.

Strand(s): Geographic Foundations: Space and Systems, Global Connections

Overall Expectations

SSV.04 - explain the use of geotechnologies in studying physical and human systems.

Specific Expectations

GC3.04 - assess the positive and negative impacts of geotechnolgies (e.g., GIS in disaster relief, GPS in military operations, satellites in monitoring nuclear sites).

Prior Knowledge & Skills

- An understanding of the main operational skills associated with *Arcview* GIS
- Experience in data and file management and the ability to navigate the school's computer network
- Ability to analyse and synthesize material and present a written report

Planning Notes

- Locate and test data before use.
- Copy data files from *ArcCanada*, Disk 2 ("world" data), to the appropriate data drive.
- Copy the "worldatnight" image from NASA's website.
- Register or georeference the "worldatnight" image. A tutorial is available on ESRI's website (www.esricanada.com/k-12/tutorials/register/index.html).

Teaching/Learning Strategies

1. The purpose of this activity is to acquaint students with the use and operation of a GIS. Constructing a map of the world, students add a series of layers or themes to an imaged map. Students also become familiar with many tools associated with a GIS, such as zooming, legend editing, identifying attributes, classifying data, and labelling.
2. Using a projector, the teacher demonstrates how to add themes from a file directory, how to identify attributes, how to edit legends, such as changing colours and line thickness, and how to classify data. Students should be reminded how to save work. Because students use an image of the world at night which shows thermal energy and not lights, the teacher demonstrates how a GIS supports images (from the Extensions option under the File menu).

3. Students analyse and draw conclusions based on the patterns that appear on the map. With an outline map of countries and other layers, such as rivers, lakes, and cities, sitting on top of the image of the world at night, many interesting patterns occur. Students zoom into regions of the world, such as the Middle East or the Sahara Desert, and report to the class on the following questions:
   - Are all brightly lit areas urbanized areas? If not, what does the map suggest about thermal energy?
   - What are the bright spots that you see in Middle Eastern areas?
   - Why does the Sahara Desert appear brighter in the south?
   - Could there be any correlations between brighter regions of the world and level of development?
   - Why do the polar regions show dim lighting?
   - What are the effects, if any, of water bodies?
   - What other interesting layers could be added to the map to produce thermal energy effects?
   - Explain how a map of this type might be useful to: NASA? Canadian military? Environmentalists?
   - Discuss other groups who might find this map useful.

Assessment & Evaluation of Student Achievement

The focus of this activity is for students to add layers to a map and begin to see patterns associated with the layers. Students can save the map as a working copy map under the View options. A mapping checklist can be used to evaluate each map. Evaluations of map components (#1) could be done by the teacher or as a peer evaluation.

T/L Strategy Number	Task/Product	Tool	Purpose	Achievement Categories
1	Adding layers or themes to a map (teacher demonstration)	Map component checklist	Formative	Knowledge/Understanding Thinking/Inquiry Application
3	Individual report analysis of mapping layers and patterns	Marking scheme or rubric	Summative	Knowledge/Understanding Thinking/Inquiry Communication

Accommodations

- Enrichment – students can learn how to register images and do a further extension of maps of specific world regions, such as Canada, with layers added.

Resources

Print

Davis, Bruce. *GIS A Visual Approach*. Onword Press. ISBN 1-56690-098-0

Mitchell, Andy. *The ESRI Guide to GIS Analysis: Volume 1: Geographic Patterns & Relationships*. ESRI Press. ISBN 1-879102-06-4

Data

Worldatnight.jpg, NASA

ESRICanada. *ArcCanada v. 2.0*, Disk 2. Toronto: ESRI Canada Schools and Libraries Program, 1999.

Websites

– http://www.nasa.gov/gallery/photo/guideline.html

– http://www.esricanada.com/english/support/faqs

– http://www.esricanada.com/k-12/tutorial/register/index.html

Software

ESRI. *Arcview 3.x*. ESRI Canada.

Activity 1.7: Culminating Activity – Making a World Map Layout for Other Applications

Time: 3.75 hours

Description

Students create a world map that is used in the geographic analysis of a specific issue. Students use basic geotechnical skills, present their findings in a properly constructed layout map, and, from this map, make conclusions about the issue. It should be noted that while there are many possible examples of issues that might be mapped and analysed, this culminating activity focuses on the issue of volcanoes. Students analyse the issue from the perspective of the biblical faith tradition and the concepts of the common good and stewardship. Teachers may choose to do other issues for the culminating activity.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE1d - develop attitudes and values founded on Catholic social teaching and act to promote social responsibility, human solidarity, and the common good;
CGE2a - listen actively and critically in light of gospel values;
CGE2b - read, understand, and use written material effectively;
CGE2c - present information and ideas clearly and honestly and with sensitivity to others;
CGE3c - think reflectively and creatively to evaluate situations and solve problems;
CGE3f - examine, evaluate, and apply knowledge of interdependent systems (physical, political, ethical, socio-economic, and ecological) for the development of a just and compassionate society.

Strand(s): Global Connections, Methods of Geographic Inquiry

Overall Expectations

GCV.01 - explain the use of geotechnologies in addressing issues of global concern.

Specific Expectations

GI1.07 - demonstrate an understanding of the conceptual and artistic factors that make for a well-designed map or graphic (e.g., good generalization, symbol contrast, balanced layout);
GI2.10 - use a variety of visual representation techniques to depict the earth's surface in novel ways.

Prior Knowledge & Skills

- An understanding of the main operational skills involved in a GIS
- The ability to navigate the school's computer network
- The ability to locate programs and data files
- Experience in designing and creating GIS maps
- Experience in presenting information to class

Planning Notes

- Photocopy information sheets for students (see Appendix 1.7.1 – Volcanoes of the World).
- Locate and test data.
- Copy *ArcCanada*, Disk 2, data to the appropriate drives. Copy the files world\w_cities.shp, world\plat_lin.shp, and world\volcano.shp.
- Give students a copy of all necessary tool buttons associated with this activity (they can be downloaded from ESRI Canada k-12 website). This allows students to work more independently.

Teaching/Learning Strategies

1. The teacher facilitates a lesson on volcanoes, including background information about volcanoes, the different types of volcanoes, and how volcanoes affect our world both positively and negatively. Students are given copies of Appendix 1.7.1.
2. With ample background information on volcanoes, students isolate specific volcanoes on the earth's surface using a GIS and analyse the possible hazards and benefits of these volcanoes to certain regions of the world. Students begin the task by locating the appropriate files and themes (countries, plate tectonic lines, and volcanoes) and adding the themes to their map of the world.
3. Once the map of the world, with tectonic plate lines and volcanoes, is created, scaled, properly projected, and saved, students perform a query on the volcano theme/layer looking for all the active volcanoes on the earth.
4. Students analyse and record the active volcanoes and determine the relationship that exists between volcanoes and tectonic plate boundaries.
5. For further research, students choose one active volcano and zoom in to the country or region where this volcano is found. Both the volcano and the region should be labelled.
6. A crucial part to any issue is analysing the potential danger to humans, therefore, students add a fourth layer to their maps – cities. The teacher sets the population classification amount (e.g., $500 000). Students determine if cities of this population size are close to his/her chosen active volcano by using the Measuring tool found in the File menu. Note: distances can only be measured if the scale has been set to kilometres.
7. Students put their created maps into a layout. The teacher should remind students of all the cartographic and graphic conventions that are necessary in producing well-designed maps. A map checklist should be available to students.
8. The final portion of this activity is to produce a well-researched and written report about the student's chosen active volcano. The report should include:
   - map analysis (name of volcano, geographic description, proximity to cities, populations, etc.);
   - the type of volcano;
   - the date of the volcano's last eruption;
   - other events associated with the eruption, e.g., earthquakes, mudflows, etc.;
   - impact on humans, plants, animals, and environmental damage;
   - benefits from the eruption.

Assessment & Evaluation of Student Achievement

Students are encouraged to combine information and skills learned in previous activities. The focus is on introductory geotechnology skills. Students display their work in a written report and/or a visual presentation. The teacher assesses the activity using checklists and rubrics.

T/L Strategy Number	Task/Product	Tool	Purpose	Achievement Categories
1	Whole-class discussion	Teacher-generated checklist	Formative	Knowledge/Understanding
2	Adding layers to a World Map (individual)	Map component checklist	Formative	Knowledge/Understanding Application
3	Querying Data (individual)	Teacher-generated checklist	Formative	Knowledge/Understanding Thinking/Inquiry

T/L Strategy Number	Task/Product	Tool	Purpose	Achievement Categories
4	Analysing and recording information on active volcanoes (individual)	Teacher-generated checklist	Formative	Communication
5	Choosing and labelling one active volcanoes (individual)	Mapping checklist	Formative	Knowledge/Understanding Application Communication
6	Measuring distances (class and individual)	Teacher-generated checklist	Formative	Knowledge/Understanding Thinking/Inquiry
7	Creating a map in layout (individual)	Mapping rubric	Formative	Knowledge/Understanding Thinking/Inquiry Application Communication
8	Presentation of findings in a written report (individual)	Report rubric based upon criteria for task	Summative	Knowledge/Understanding Thinking/Inquiry Application Communication

Accommodations

- Lesson instructions, complete with exemplars, could be photocopied then discussed in small group sessions with students who have communication difficulties. Review paragraph structure and formats.
- For enrichment, students could examine other natural disasters or issues.

Resources

Data

World data from ESRI Canada. *ArcCanada v. 2.0,* Disk 2. Toronto: ESRI Canada Schools and Libraries Program, 1999.

Websites

– http://esricanada.com/k-12/index.html

Software

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Appendix 1.7.1

Volcanoes of the World

A) Question and Answer Session about Volcanoes

What is a volcano? A volcano is a mound, hill, or mountain constructed by solid fragments, lava flows, and/or dome-like extrusions deposited around a vent from which the material is extruded. The vent is like a valve that extends from the earth's upper mantle or lithosphere to the surface. Most of the material is deposited close to the vent, but some is carried high into the atmosphere to be spread by winds hundreds or thousands of kilometres from the source.

Why do volcanoes erupt? It is so hot inside the earth that some rocks slowly melt and become a thick flowing substance called magma. Magma is lighter than the solid rock around it, and some eventually pushes through vents and cracks in the earth's surface. This is known as an eruption.

Where are they found? The location of volcanoes is related to plate tectonics and hotspot activity. There are 16 major plates of the earth's crust. Rigid plates float on a softer layer of rock in the earth's mantle. As plates move, they push together, pull apart, or move parallel to each other.

There are three main areas of volcanic activity

- *Subduction zones:* When plates push together, one plate slides underneath the other. When the plunging plate gets deep enough inside the mantle, some of the rock on the overlaying plate melts and forms magma that can move upward and erupt at the earth's surface.
- *Rift zones:* Areas where plates are moving apart and magma comes to the surface and erupts.
- *Hotspots:* Some volcanoes occur in the middle of plates. Hotspots are places where magma melts through the plate and erupts. For example, the Hawaiian chain of volcanoes is not located along plate boundaries. It is believed that they have erupted in a sequence as the moving oceanic plate passed over a hotspot or mantle plume. This caused eruptions but didn't break up the plate.

B) Types of Volcanoes

There are many ways to classify volcanoes. Here are a few of the main types.

Shield Volcanoes: Form from eruptions of flowing lava. The lava spreads out and builds up volcanoes with broad, gently sloping sides.

Cinder Cone: A small, cone-shaped hill usually less than 450 m (1500') high. They have truncated tops from cinders that accumulate during moderately explosive eruptions.

Composite Volcanoes (Stratovolcanoes): Build up from multiple eruptions over time of lava and tephra that pile up in layers, or strata, much like layers of cake and frosting! They form symmetrical cones with steep sides. Stratovolcanoes are located mainly in two chains:

- *The Circum-Pacific belt (The Ring of Fire):* They are found along the West Coast of South, Central and North America, turns west in Alaska and the Aleutians, goes south through Japan, the Philippines, Indonesia, the South Pacific, and New Zealand.
- *The Mediterranean belt:* (Extends from just west of Northern Africa down to Asia Minor)

Caldera (Spanish for Kettle): A large, basin-shaped depression. Forms when the summit material on a volcanic mountain collapses inward after an eruption or other loss of magma.

Appendix 1.7.1 (Continued)

Types of Eruptions

Effusive Eruptions: Relatively gentle eruptions which produce enormous volumes of lava. Gases readily escape from the magma because of its texture. Magma pours out onto the surface, with relatively small explosions and small amounts of tephra. Shield volcanoes are typically built from this type of eruption.

Explosive Eruptions: Magma tends to be thicker in this case and blocks the coduit inside the volcano. Pressure builds, and eruptions are violent and literally explosive! Composite volcanoes normally experience explosive eruptions.

C) How Do Volcanoes Affect Our World?

The Lithosphere: (the hard, outermost shell of the Earth): Volcanoes alter the lithosphere by dramatically changing mountain size, shape, and structure. They also create landforms.

The Atmosphere: Volcanoes erupt materials into the atmosphere, such as water vapour, carbon dioxide, sulfur dioxide, chlorine, and fluorine.

- *Water Vapour:* Water vapour added to the atmosphere is beneficial because it adds to the earth's water supply.
- *Carbon Dioxide:* Volcanoes contribute about 110 million tons of carbon dioxide per year into the atmosphere. Human activities contribute approximately ten billion tons per year. The problem is complex, for volcanoes can help cool the earth's surface by adding aerosols which reflect the sun's rays, and also contribute to the greenhouse effect by injecting carbon dioxide into the atmosphere.
- *Sulphur Dioxide:* The greatest volcanic impact upon the earth's short-term weather patterns is caused by sulphur dioxide gas. Sulphur aerosols last many years, and several historic eruptions show a good correlation of sulphur dioxide layers in the atmosphere with a decrease in average temperature of subsequent years.
- *Chlorine:* Chlorine is emitted from volcanoes in the form of hydrochloric acid (HCI). These molecules mix with other forms of chlorine in the atmosphere and act to destroy ozone.
  Fluorine: Fluorine gas can condense in rain or ash particles and coats grass and pollutes streams and lakes. Small amounts can be beneficial, but excess amounts can be life threatening to animals. Animals that eat grass coated with fluorine-tainted ash are poisoned.

The Hydrosphere: (Liquid water on and under the Earth's surface) The hydrosphere can make volcanic eruptions more dangerous. When water mixes with rock and mud, it can create volcanic mudflows (lahars).

The Cryosphere: Ice and snow melt during volcanic eruptions. This can cause dramatic events, especially if a volcano is situated on a snow or ice-capped mountain.

Appendix 1.7.1 (Continued)

D) Hazardous Volcanic Events

There are several kinds of events caused from volcanic action that can be harmful to life and property.

Pyroclastic Density Currents: Rapidly moving, ground-hugging mixtures of rock fragments and hot gases. Temperatures can be as high as 900 degrees Celsius, or as cold as steam. Deadly effects include asphyxiation, burial, incineration, and crushing from impact. The only effective method of decreasing risks is evacuation prior to such eruptions from areas likely to be affected by these events.

Lahars: Fluids composed of mixtures of water and particles of all sizes from clay to gigantic boulders. They form by any process in which volcanic particles can become saturated by water and move down slopes. They have been known to travel as far as 300 km. Lahars can transform into regular floods as they become increasingly diluted with water downstream.

Lava Flows: Rarely threaten human life because lava usually moves slowly. Major hazards of flows are burying, crushing, covering, and burning everything in their path. Lava flows can dam rivers to form lakes which might overflow and break their dams causing floods. Methods for controlling paths of lava flows:

1. Construct barriers and diversion channels.
2. Cool the advancing flow with water.
3. Disrupt the advancing lava flow with explosives.

Tsunamis: A tsunami is a long-period sea wave or wave train generated by a sudden displacement of water. The incorrect, but popular, term is a tidal wave. Tsunamis travel at very high speeds through deep water as low broad waves and build up to great heights as they approach the shallow bottom of shores. Most are caused by fault displacements on the sea floor, but many have been caused by volcanic action.

E) What Are the Benefits from Volcanism?

- The earth's water and atmosphere that evolved from the gases produced by volcanic eruptions
- Formation of rich volcanic soils
- The creation of geothermal power
- The development of health spas and hot springs for recreation
- Hydroelectric power from rivers flowing off large volcanoes
- Recreational activities, such as skiing, hiking, tourism, and visiting volcano sites
- Source for precious gems
- Source for metals, such as gold, silver, copper, zinc, lead, and mercury
- Archaeological sites
- Construction materials for things like roads, cinder athletic tracks, and water-resistant concrete from volcanic ash
- Others include: gas and oil wells, kitty litter, stone-washed jeans with pumice, volcanic glass shards for polishing compounds and abrasives in toothpaste, and kitchen cleansers