1. GIS Program and Its Context

In recent years, there has been a continuing stream of fundamental advances in the development of geographical information systems (GIS) in a number of disciplines having a spatial information focus, including geography. Individuals, groups, organizations, and private-public partnerships adopt GIS as an effective means for dealing with large data sets, where location is of particular significance to address complex problems. These data sets are essentially an extension and enhancement of the nature of maps in a variety of ways.

GIS and related geospatial technologies are used to carry out geographic modeling and analysis of this information from the local to global scales. Some of the GIS applications include, but are not limited to, changes in resource-based industries such as forestry, fisheries and agriculture in this region and around the world, urban growth management both in this country and other countries, economic restructuring in this country and around the world, local and global environmental change and the human component in this change, and other issues of local, regional, national and international significance. Although the specific information requirements differ across this range of applications, there are many commonalities in the underlying data management, analysis, and display tools used.

GIS development has been driven by diverse application needs, and also in part due to the intellectual interest of developing the concepts behind the technology. The roots of GIS can be traced to the mid-1960’s, some activity of which occurred in Geogaphy at the University of Washington. Over the past several years interest in developments of concepts behind the substantive needs and methodological approaches has broaden GIS into a Geographic Information Science (GISci) perspective. Many programs in GIS, including GIS in Geography at the University of Washington (UW), have followed a GISci perspective since their inception – as sound concepts are what drive information system solutions – but have only recently started using the GISci descriptor.

The Geography Department works with other units on the UW campus in fostering a creative instruction and research environment for both undergraduate and graduate students. The GIS program in the Department of Geography provides education to many undergraduate and graduate students who find positions in academe, research institutes, government agencies, and private industry around the world. The local internship program has been quite effective in providing students a learning experience integrated with their education.
2. GIS Faculty and Their Focus

Professors Chrisman and Nyerges are the principal faculty involved in GIS in the Department of Geography at UW. They both have international reputations in GIS due to several contributions to the field in both instruction and research. Professor Nyerges was recruited to the UW faculty in 1985, after five years of private industry GIS software design experience. Professor Chrisman was recruited in 1987 after 10 years of software research and development at Harvard Lab for Computer Graphics and Spatial Analysis, followed by 5 years of academic research experience at the University of Wisconsin-Madison. Since their arrival on campus, they have established leadership positions in GIS. The underlying philosophy in the GIS program is to create a synergistic atmosphere among instruction, research, and public service. To do this, program focuses on issues of comparative GIS data processing approaches in the following specific topic areas.

- Developing new components for spatial problem solving, including:
  - metadata management techniques in support of information use
  - spatial data quality in support of information use
  - object-oriented database approaches
  - systems integration by coupling environmental models & GIS, and
  - group-based, decision support systems development
- Testing new developments on realistic applications focusing on sustainable development concerns, particularly including:
  - urban growth management
  - land resource management
  - land records management
  - environmental contamination
- Linkage between GIS and Society
  - spatial cognition in complex problem solving
  - collaborative decision making
  - social impacts as costs, benefits, values, and ethics of GIS
  - social construction of GIS

3. GIS Instruction

The GIS instructional program consists of the following ten courses.

Geography 258 Maps and GIS (5)
Exposure to the art and science of mapping, and how GIS software is changing who makes maps and how they are used.
Prerequisite: None
Scheduling: Winter Quarter; Offered as staff is available
Instructor(s): Chrisman or graduate student instructor

Geography 360 Principles of Cartography (5)
Origins, development and methods of cartography. Principles of data representation and map design for thematic and topographic mapping. Introduction to the use of computers for mapping. Previous computer experience is not necessary.
Prerequisite: None
Scheduling: Offered yearly in autumn and spring quarters
Instructor(s): Nyerges (Aut) and Chrisman (Spr)

**Geography 458 Map Sources and Errors (5)**
Analysis and appraisal of source materials for maps, production constraints of mapping agencies, coverage and quality. Focus on errors inherent in maps and map-derived data.
Prerequisite: Geography 360
Scheduling: Offered every other year in the winter quarter
Instructor(s): Chrisman

**Geography 460 GIS Analysis (5)**
Methods of analysis provided by geographic information systems. Transformations of geographic information including map overlay, aggregation/disaggregation, point, line and polygon processing, and others. Vector and raster data structure issues. Reviews capabilities of currently available GIS software.
Prerequisite: Geography 360
Scheduling: Offered yearly in the autumn quarter
Instructor(s): Chrisman

**Geography 461 Urban Geographic Information Systems (5)**
Use of geographic information systems to investigate urban/regional issues; focus on transportation and land-use issues, but all urban change problems are considered. Geographic information processing strategies. Problem definition for GIS processing. Data collection and geocoding issues. Data structuring strategies. Projects focus on street network, land parcel and census data.
Prerequisite: Geography 360
Scheduling: Offered every year in the winter quarter
Instructor(s): Nyerges

**Geography 463 Geographic Information Systems Workshop (5)**
Studio course in geographic information systems use. Topic changes year to year depending on interest of students and faculty and community need at specific time of offering. Student groups propose topics in cooperation with instructor. Problem definition, data gathering, manipulation, analysis, and display of information in a realistic application development setting.
Prerequisite: Geography 460 or 461 and senior or graduate standing.
Scheduling: Offered every year in the spring quarter.
Instructor(s): Chrisman or Nyerges

**Geography 465 Analytical Cartography (5)**
Algorithms and data structures for selected topics in analytical cartography. Emphasis on point, line, area and surface data representation, map design, generalization, and data transformations in a systems development context. Programming exercises make use of a software objects library.
Prerequisite: Geog 360, background in Visual Basic (or other) compiler
Geography 520 Research Seminar on Geographic Information Representation (5)
Current topics in geographic information representation and use, e.g. problem solving and decision making with GIS. Discussions are based on assigned readings or personal research projects. Students prepare research paper proposal, outline, literature review, and final paper related to the topics covered in discussions. Research material is presented in class for evaluation and critique. The seminar provides an opportunity for developing thesis and dissertation proposals.
Prerequisite: graduate status or permission of instructor and background in geographic information systems. Can be taken twice
Scheduling: Offered yearly in the spring quarter
Instructor(s): Nyerges

Geography 560 Research Seminar on Geographic Information and Analysis (5)
Current research topics in aspects of geographic information and analytical methods to treat it. Seminar usually focuses on a specific topic according to student interests. Discussions are based on assigned readings or personal research projects. Students prepare research materials including a proposal, outline, literature review and final paper related to the topics covered in discussions. Research material is presented in class for evaluation and critique. The seminar provides an opportunity for developing thesis and dissertation proposals.
Prerequisite: graduate status with background in geographic information systems. Can be taken twice.
Scheduling: Offered yearly in the winter or spring quarter
Instructor(s): Chrisman

Geography 563 Algorithms and Data Structures for GIS (5)
Prerequisite: Geography 465
Scheduling: Offered every other year in the spring quarter, if staffing permits
Instructor(s): Chrisman

The above ten courses provide opportunities for learning in line with various learning objectives (Table 1) according to four levels of outcome. The outcomes provide a student with a sense of expected competency (Table 2). Each learning objective topic is further detailed in Table 3. (See Appendix A for detailed outcome rubric by course.)
Table 1. GIS Learning Objectives and Expected Level of Learning Outcome by Course

<table>
<thead>
<tr>
<th>Lrn Obj Num</th>
<th>Learning Objective Topics (ACRL Performance Indicator)</th>
<th>UW Geography GIS Concentration Courses² (cell entry - expected level of student competency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perspectives on GIS for representing data, information, knowledge – interplay among reality, database, and map display (ACRL Ind 3.4)</td>
<td>§ 285 § 360 § 458 § 460 § 461 § 463 § 465 § 520 § 560 § 563</td>
</tr>
<tr>
<td>2</td>
<td>Analytical and communication perspectives on representation</td>
<td>1 2 3 3 3 3 3 3 3 4 4 4 3</td>
</tr>
<tr>
<td>3</td>
<td>Geographic concept abstraction as relationship among geographic phenomena, object types, and data measurements (ACRL Ind 3.3)</td>
<td>2 2 3 3 3 3 4 4 4 4</td>
</tr>
<tr>
<td>4</td>
<td>Data sources (ACRL Ind 1.2) primary data sources secondary data sources Census TIGER, WAGDA</td>
<td>1 1 3 2 2 3 3 3 3 2 2 2 2</td>
</tr>
<tr>
<td>5</td>
<td>Data collection/acquisition/entry approaches, technology, and formats (ACRL Ind 2.1)</td>
<td>1 1 3 2 2 3 2 - - -</td>
</tr>
<tr>
<td>6</td>
<td>Data search, compilation, and integration (ACRL Ind 2.2)</td>
<td>2 2 3 3 3 4 4 2 2 -</td>
</tr>
<tr>
<td>7</td>
<td>Surveys and coordinate systems for spatial referencing</td>
<td>2 3 3 3 3 4 4 4 4 4</td>
</tr>
<tr>
<td>8</td>
<td>Map projections</td>
<td>1 2 2 3 3 3 4 2 2 4</td>
</tr>
<tr>
<td>9</td>
<td>Map type displays - General/reference - Thematic: Choropleth, Dot, Flow, Proportional Symbol, 2D Surface/Isarithm, 3D Surface and Solids</td>
<td>2 3 3 3 3 4 4 4 4 4</td>
</tr>
<tr>
<td>10</td>
<td>Map Layout as Design Graphic Hierarchy Intellectual Hierarchy</td>
<td>2 3 1 2 2 3 3 3 3 3 3</td>
</tr>
<tr>
<td>11</td>
<td>Symbolization as design Graphic variables and color use</td>
<td>2 3 2 3 3 3 3 3 2 2 2</td>
</tr>
<tr>
<td>12</td>
<td>Generalization as design Classification, Selection, Simplification, Induction</td>
<td>1 2 3 3 3 3 4 2 2 4</td>
</tr>
<tr>
<td>13</td>
<td>Visual cognition as map use Cognitive Skills (identify, recognize, understand, knowing, demonstrating, applying)</td>
<td>1 2 1 2 2 3 3 4 - -</td>
</tr>
<tr>
<td>14</td>
<td>GIS use as critical thinking (ACRL Ind 1.4) and geospatial problem solving (ACRL Ind 3.1) by individuals, groups, and organizations (ACRL Ind 3.6, 4.1) for problem exploration, planning, risk management, decision making</td>
<td>1 2 2 3 3 3 1 3 3 2</td>
</tr>
<tr>
<td>15</td>
<td>GIS data structures; object types: point, line, polygon, and surface</td>
<td>1 3 3 3 3 4 4 2 2 4</td>
</tr>
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<td>---</td>
</tr>
<tr>
<td>16</td>
<td>GIS data management (ACRL Ind 2.3, 2.4, 2.5)</td>
<td>1</td>
</tr>
</tbody>
</table>
| 17 | GIS data analysis
              geometric measurement
              data manipulation
              spatial analysis | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 2 | 2 |
| 18 | GIS information visualization | 2 | 3 | 2 | 3 | 3 | 4 | 4 | 2 | 2 |
| 19 | Data quality and consequences of use, including lineage, positional accuracy, attribute accuracy, logical consistency, completeness (ACRL Ind 3.2, 5.3) | 1 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| 20 | Application case studies
              focus on sustainable development issues for natural resource, transportation, land cover, land use, zoning, ecosystems, environmental hazards | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| 21 | Project/product presentation (ACRL Ind 4.3) | 1 | 1 | 3 | 3 | 4 | 1 | - | - |
| 22 | GIS data models and database structures – linking spatial and attribute data | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | - |
| 23 | Database design process
              - Conceptual (ACRL Ind 1.1), Logical, and Physical design | - | 1 | 2 | 2 | 3 | 3 | 2 | 4 | - |
| 24 | GIS project management
              - Gaining organizational support through cost and benefit study (ACRL Ind 1.3)
              - Workgroup management (ACRL Ind 4.2)
              - Project workflow steps (ACRL Ind 1.4, 3.7)
              - Milestones and budgeting | 1 | 1 | 1 | 1 | 2 | 3 | 2 | 1 | 1 |
| 25 | GIS implementation and critical evaluations of GIS use in society; community participation, value conflicts (ACRL Ind 3.5, 5.1, 5.2) | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 4 | 4 |
| 26 | Algorithms and programming
              - software programming language
              - GIS components | - | - | 2 | 2 | 2 | 2 | 3 | 2 | 2 |
| 27 | Systems design and architecture
              - data architecture
              - software architecture
              - hardware architecture | - | - | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 4 | 4 | 4 | 4

2Course number and name:
- Geography 258 Maps and Geographic Information Systems
- Geography 360 Principles of Cartography
- Geography 458 Map Sources and Error
- Geography 460 Geographic Information Analysis
- Geography 461 Urban Geographic Information Systems
- Geography 463 Geographic Information Systems Workshop
- Geography 465 Analytical Cartography
- Geography 520 Seminar in Geographic Information Representation
- Geography 520 Seminar in Geographic Information and Analysis
- Geography 563 GIS Algorithms and Data Structures

3Expected level of student competency (See Table 2 for details of levels by course objective):
- : not introduced, hence competency not expected in course
1 : “knowledge” involves awareness of its significance
2 : “comprehension” involves “understanding the principles” associated with topic
3 : “application and analysis” involves the demonstrated use of the topic
4 : “synthesis and evaluation” involves a base level of “mastery” to address the topic
<table>
<thead>
<tr>
<th>Lrn Obj Num</th>
<th>Learning Objective Topics</th>
<th>Performance Assessment of Learning Outcomes¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perspectives on GIS for representing data, information, knowledge – interplay among reality, database, and map display (ACRL Ind 3.4)</td>
<td>0  Not acceptable 1 Knowledge Awareness 2 Comprehend and Explain 3 Apply and Analyze 4 Synthesize and Evaluate</td>
</tr>
<tr>
<td>2</td>
<td>Analytical and communication perspectives on representation</td>
<td>No familiarity with representing data Maps represent features of the world Data and maps represent the world in different ways Use data to create map information abstracting aspects of a world</td>
</tr>
<tr>
<td>3</td>
<td>Geographic concept abstraction as relationship among geographic phenomena, object types, and data measurements (ACRL Ind 3.3)</td>
<td>All are the same, no difference is detected Differentiate among the character of phenomena, object types, and data measurement Use phenomena, object type, and measure in appropriate way in a GIS tool Make a pair-wise comparison to tweek the best out of each level Design a new way to make use of each in a robust way</td>
</tr>
<tr>
<td>4</td>
<td>Data sources (ACRL Ind 1.2) primary data sources secondary data sources Census TIGER, WAGDA</td>
<td>All data are the same Data represent character of features Able to measure character of features in a database Able to use data appropriately to level of measurement character Differentiate the way levels of measurement represent character of features</td>
</tr>
<tr>
<td>5</td>
<td>Data collection/acquisition/entry approaches, technology, and formats (ACRL Ind 2.1)</td>
<td>Know about one or two formats, but not know why they exist Differentiate formats in a general way as data for an application Describe different formats needed for software Make use of a wide range of approaches and formats Explain the advantages of using different application formats</td>
</tr>
<tr>
<td>6</td>
<td>Data search, compilation, and integration (ACRL Ind 2.2)</td>
<td>Do not understand how data search influences information outcomes Know that data search influences information outcomes Understand how a search develops into different information outcomes Able to use multiple search strategies to enhance information outcomes Develop a new data search strategy; other strategies do not seem to provide information needed</td>
</tr>
<tr>
<td>7</td>
<td>Surveys and coordinate systems for spatial referencing</td>
<td>Surveys and coordinate systems are the same thing A reference grid is used to express a point position in a coordinate system Surveys establish control for coordinate systems How to differentiate and use a coordinate system Work with a tool to project between different coordinate systems</td>
</tr>
<tr>
<td>8</td>
<td>Map projections</td>
<td>Maps are flat; and the earth is not much different The earth and a flat display have a relationship called a projection transform Distoration comes in different forms, and is related to projection choice Use projections to display data in appropriate way Why chose one projection over another based on minimizing distortion for a particular purpose</td>
</tr>
</tbody>
</table>
|   | Map type displays  
- General/reference  
- Thematic: Choropleth, Dot, Flow, Proportional Symbol, 2D Surface/Isarithm, 3D Surface and Solids | Not able to understand that maps represent different aspects of the world | Know that different maps present a different message | Understand that different types of maps are based on graphical variables | Make a map of each of the different types and explain the use of each graphical variable | Make of map of each type and create a scheme for changing how maps represent information |
|---|---|---|---|---|---|
| 10 | Map Layout as Design  
Graphic Hierarchy  
Intellectual Hierarchy | Not knowing what map components are used on a map | Identify map components describe | How the map components relate to the overall map | Make maps that use visual and intellectual hierarchy of components | Explain how visual and intellectual hierarchy support each other in design |
| 11 | Symbolization as design  
Graphic variables and color use | Recognize graphic marks, but unsure of use | Recognize the graphic variables | Make use of graphic variables in a map | Make use of graphic variables in a variety of maps | Combine use of the graphic variables on maps |
| 12 | Generalization as design  
Classification, Selection, Simplification, Induction | Not know about generalize in mapping | Know that generalize is used in mapping | Understand that generalizing in mapping is to make clearer by simplifying | Apply and analyze data to create a generalized data set | Synthesize and evaluate reasons for generalizing data on a map |
| 13 | Visual cognition as map use  
Cognitive Skills (identify, recognize, understand, knowing, demonstrating, applying) | Unsure why cognition is important in mapping | Describe important qualities of cognition in map use | Describe how cognition works in mapping | Explain how and why cognition works in mapping | Change a tool that can change an aspect of cognition in mapping |
| 14 | GIS use as critical thinking  
(ACRL Ind 1.4) and geospatial problem solving (ACRL Ind 3.1) by individuals, groups, and organizations (ACRL Ind 3.6, 4.1) for problem exploration, planning, risk management, decision making | Unaware that maps can assist people with thinking through geospatial problems | Describe how critical thinking can improve GIS use in one of the types of geospatial problem solving processes | Explain how critical thinking can improve GIS use in any one of the geospatial problems solving contexts | Apply a critical thinking process to improve GIS use in any of the geospatial problem solving contexts | Change a tool to improve the use of GIS for critical thinking during geospatial problem solving |
| 15 | GIS data structures; object types: point, line, polygon, and surface | Confuse data with graphical symbols used to portray data - they are the same thing | Describe data structuring in terms of point, line, polygon, and surface data structures for analysis or display | Explain the difference among point, line, polygon, and surface data structures for analysis or display | Use a GIS tool for an application that makes use of point, line, polygon, and surface data structures for analysis or display | Show use of a tool or construct a tool and explain why point, line, polygon, and surface representation are needed to satisfy different requirements |
| 16 | GIS data management (ACRL Ind 2.3, 2.4, 2.5) | Data are stored in a computer somehow | Describe the basic components of database structures in terms of tables, files, records, fields | Explain how tables, files, records, and fields compose database structures, and how operations occur on these structures | Show and explain how to use a database management system such as MS Access to support analysis and/or display | Differentiate and evaluate the use of various database structures for representing geospatial information in analysis and display |
| 17 | GIS data analysis  
geometric measurement  
data manipulation  
spatial analysis | Data goes in a computer and you get output  
Data can be analyzed by software and one can obtain different results depending on software  
Data is manipulated to create information, but exactly what steps to take is not known  
Show a variety of spatial analyses in creating a variety of information  
Develop a tool that can perform different kinds of analysis not currently available in the GIS | | | |
| 18 | GIS information visualization | Data is displayed on a screen by a computer  
Displays are created by software using a variety of data  
Different software can create different types of displays  
Use data management, display, and analysis software together in a GIS to create information  
Make a change in a tool for enhanced visualization in a GIS mapping context | | | |
| 19 | Data quality and consequences of use, including lineage, positional accuracy, attribute accuracy, logical consistency, completeness (ACRL Ind 3.2, 5.3) | Data is all the same good quality  
Data are all different quality, but uncertain of how and why  
Data are of different quality, and can briefly explain why  
Data are of different quality and can perform tests to show how and explain why  
Change a tool in some way to manipulate data quality to enhance the use of data in creating information | | | |
| 20 | Application case studies  
focus on sustainable development issues for natural resource, transportation, land cover, land use, zoning, ecosystems, environmental hazards | GIS can be used for a lot of different things, but no specifics come to mind  
Identify and describe a number GIS application cases  
Briefly explain the advantages of using GIS in a variety of application situations  
Apply GIS capabilities in at least one problem context and explain its use in light of one or more case examples  
Synthesize and evaluate advantages and disadvantage based on experience with using GIS | | | |
| 21 | Project/product presentation (ACRL Ind 4.3) | Free association talk about a project and maps as a presentation  
Describe a few sections of an outline for a project and/or product  
Explain why an outline in sequenced sections is a good approach for a project presentation  
Use an outline to sequence sections for a project presentation that includes GIS maps; and all sections presented  
Suggest a revised outline to meet the needs of a presentation to an audience; and all sections are done well | | | |
| 22 | GIS data models and database structures – linking spatial and attribute data | GIS data is just in computer, without knowing different approaches are needed  
Describe the basics of a GIS data model used to store a database structure  
Explain why different GIS data models are suitable to different data storage requirements  
Apply one or more GIS data models as a database structure for addressing a GIS data problem  
Iteratively redesign a GIS database structure to meet analysis requirements | | | |
| 23 | Database design process  
- Conceptual (ACRL Ind 1.1), Logical, and Physical design | Someone puts data in a computer somehow  
Recognize and describe different stages of database design  
Explain why each stage of database design is important  
Use a three-step process to develop a database design  
Iteratively develop a database and explain why changes were needed as the problem was further understood | | | |
| 24 | GIS project management | Get a bunch of stuff together for a GIS project | Able to describe the usefulness of a project plan and several of the components that compose a plan | Move forward to apply a project plan and assign technical, personnel, financial, and temporal components | Revise and refine a GIS project plan based on technical, personnel, financial, and temporal constraints |
| 25 | GIS implementation and critical evaluations of GIS use in society; community participation, value conflicts (ACRL Ind 3.5, 5.1, 5.2) | Unaware that GIS has an impact on society | Describe how GIS outcomes can impact society | Explain why GIS has an impact on society | Demonstrate through application how GIS can have an impact on society | Synthesize and evaluate a new type of impact of GIS on Society on the basis of previous experience with applications of GIS |
| 26 | Algorithms and programming | Unaware how software language is used to compose new tools and components for GIS | Describe how a software language can be used to construct a program | Explain how one software language can be superior to another for use in constructing a new tool or component for GIS use | Apply experience with software languages to program a new GIS tool | Construct new system of tools based on reasoned judgement to expand GIS concepts, techniques, and software in a major way |
| 27 | Systems design and architecture | No awareness of geospatial data, software and hardware and the relationship among them | Describe components of geospatial data, software, and hardware | Explain how and why geospatial data, software and hardware are related to each other | Design an architecture to address a realm of geospatial problems | Synthesize and evaluate a few GIS architectures to address a realm of geospatial problems |

1Bloom’s Taxonomy of Cognitive Skills
http://illinois.online.uillinois.edu/IONresources/assessment/bloomtaxonomy.html
Table 3. Topics in the Instructional Program

1. **Perspectives on GIS** – representations of data, information, and knowledge from multiple perspectives. The interplay among a multi-valued reality and intentions for database and map display representations can change interpretations of data, information, and knowledge.

2. **Analytical and Communication Perspectives** – two approaches to working with representations of geographic data have predominated the study of mapped information over the past 40 years - maps as an analytical tool and maps as a communication device.

3. **Geospatial Concept Abstraction** - relationship among geospatial phenomena, object types, and data measurements as related to forms of data representation

4. **Source Materials** -- the materials used in compiling and updating maps through manual means and digital data sets; review relationship to topics in measurement sciences such as surveying and photogrammetry; advanced topics include analysis and appraisal of materials, geographic coverage, and aspects of data quality.

5. **Data Collection** -- the digitizing process, including both manual and semi-automated techniques.

6. **Data search, compilation and integration** -- the process of compiling digital data sources, including both digital and analog (hard copy map) data sources; emphasis is placed on resolving divergent and potentially incompatible sources in overlay analysis.

7. **Surveys and coordinate systems** – surveys and coordinate systems as related to spatial referencing systems, geographical (latitude and longitude) and planar (state plane and universal transverse mercator) coordinate systems used to express locational information with reference to a datum. Datum reference includes discussion of the geoid and ellipsoids with particular discussion of coverage and use of coordinate systems in spatial reference frameworks.

8. **Map projections** – classification and selection of map projections and map transformations for small scale and large scale maps, including projections used by the U.S. Geological Survey, and coordinate data transformations for computer graphics.

9. **Map type displays** – general reference and thematic maps; basic types of point, line, area, and volume maps depicting spatial patterns; map types: choropleth, dot, flow, proportional symbol, 2D surface and isarithms, 3D surface and solids.

10. **Map layout as design** -- fundamental issues in designing maps, including visual hierarchy, intellectual hierarchy, audience objectives, components of balance and contrast in promoting hierarchy, and basic elements that determine effective symbolization.

11. **Symbolization as design** -- different types of point, line area and volume symbols generated from the use of graphic design principles.

12. **Generalization as design** -- techniques and procedures used to reduce the amount of detail in a database or a map graphic. Different methods apply to point, line and area
data, including both geometric and attribute procedures such as selection, classification, simplification, induction, and filtering operators.

13. **Visual cognition as map use** -- the process of interpreting graphic information on a map, including the processes of perception and recall from short term and long term memory; cognitive visualization principles.

14. **GIS use as critical thinking and geospatial problem solving** -- fundamentals of spatial logic underlying the use of spatial operators; problem solving strategies with spatial information; operational and cognitive aspects of information use; includes analysis of problem domains and work tasks to determine how information is used in particular contexts; advanced topics include the foundations of reasoning, problem solving and decision making from mathematics, philosophy, management /decision science, and cognitive science.

15. **Data structures** -- fundamentals of organizing data for storage, management, analysis and display using programming languages, including locational, temporal and thematic characteristics of data.

16. **GIS data management** -- concept, techniques, and tools for managing spatial and attribute data in support of analysis and display.

17. **GIS data analysis** -- manipulating point, line, area and volume data to derive other point, line, area, and volume data, including conversions of one to another; used for investigating spatial pattern as a data distribution across a surface and spatial process as the change in patterns over time.

18. **GIS information visualization** – use of analysis and display capabilities together to enhance insight into interpretation of geographic information.

19. **Data quality and consequence** -- Types of errors that exist in spatial data and their influence on spatial models and the decisions derived from such models. It includes all testable components of data quality: positional and attribute accuracy, logical consistency, and completeness.

20. **Application case studies** -- case studies for particular topics of interest to students in class; appropriate application processing strategies for particular problems of interest including but not limited to sustainable development issues about natural resources, transportation, land use, ecosystems and environmental hazards.

21. **Project/product presentations** -- strategies for making presentations in line with standard professional practice.

22. **GIS data models and database structures** – frameworks for spatial database management systems including storage constructs, operations and integrity rules; compares database management approaches to file management approaches, and uses spatial database management software.

23. **Database design** -- the process of designing conceptual, logical and physical data descriptions for implementing single and multipurpose geographic databases.

24. **GIS Project management** – needs analysis, requirements definition, gaining
organizational support through cost-benefit studies, workgroup management, project
workflow, milestones and budgeting.

25. GIS implementation and critical evaluations in society -- cartography and
geographic information systems in their cultural and institutional settings in society
including private and public organizations, communities, private-public partnerships.

26. Algorithms and programming -- specification, design, and implementation of software
for geographic data processing.

27. Systems design & integration -- different types of information systems architectures,
how they interface to one another, including the interfacing of spatial modeling, GIS,
remote sensing, and management information systems.
4. GIS Research Activities

Several research activities are underway in the Department. Some of these are:

- GIS for Group Decision Support. GIS by its very nature is a cooperative, computing-based environment. This project examined the use of GIS as a core technology for support of decision making in environmental restoration. This topic by its nature is a cooperative effort because of the complexity of the issues involved, and the number of viewpoints used in bringing perspective to solutions.

- Social Construction of GIS. Investigates how the software, data and results of a GIS were assembled in specific social context. Places specific emphasis on disciplinary culture and institutional memory.

- Accuracy Testing. There have been experiments on vector testing of a forestry inventory of Northern California for California Department of Forestry (subcontract to Geography at U C Santa Barbara), and participation on a Task Force for National Marine Fisheries Service Coastwatch program.

- GIS for Risk Evaluation. This project explores the use of GIS for risk evaluation in the context of hazardous waste cleanup. Risk evaluation includes problem formulation, risk assessment, risk analysis, risk management, and risk monitoring.

- Visualization of Virtual Worlds. This project is examining advanced visualization techniques for virtual worlds technology. Focus is on visualization of data uncertainty.

- GIS and Transportation Decision Making. Project investigates the use of group-based decision support technology for transportation improvement program decision making.

- Metadata Clearinghouses and Regional collaboration. The Department has cooperated with other campus units to assist in constructing a regional clearinghouse for geographic information covering the Olympic Peninsula.

- Geography of Geographic Information. This initiative attempts to pull together an understanding of the variation around the world in the production and consumption of geographic information. This effort will mobilize an international network of collaborators.
5. Information Technology Resources

E-mail
Email, using the UW’s “Uniform Access Computers” (or “UAC’s”) is available from just about any PC or workstation on campus.

Sherman Lab
The Sherman Lab (Smith 401) houses thirty Pentium III workstations. The Pentiums are used primarily for cartography and GIS courses (360, 460, 461, 463). They are available whenever labs are not being held, with TA’s doing TA-related work having precedence. Software available on the Pentium machines includes Microsoft Office (Word, Excel, Access) ArcView 3.X and Arc/Info NT.

No food or drink is allowed in this lab.

Collaboratory and Scholars’ Work Area
Smith 415 is divided into two parts: the Collaboratory and the Scholars’ Work Area. The Collaboratory is used for classes where student collaboration is emphasized. This room houses 7 Pentium III computers. Six of the computers are at work tables designed for collaborative work. Each of these workstations has a large screen display. The seventh computer, in the center of the room, is used as the instructor’s workstation during classes.

The printers at CSSCR (Savery Hall basement) or Suzallo can be used for personal work.

The Scholars’ Work Area houses 2 Pentiums, 2 Power Macs, a library catalog terminal, and a scanner. The scanner is connected to the Pentium beside it. This area is mainly for faculty and grad students’ research.

No food or drink is permitted in this lab.

Commons Area
Smith 411 contains eight Pentium II 400 computers and a printer for student use. All software available in Smith 401 and 415 is also available in Smith 411.

Around Campus
There are many computer labs around campus. A good information source for hours, etc., is the UW’s web page, http://www.washington.edu/tech_home/Labs.html
<table>
<thead>
<tr>
<th>Lrn Obj Num</th>
<th>UW Geography 360 Principles of Cartography Learning Objective Topics Instructor: Nyerges</th>
<th>Performance Assessment of Learning Outcome¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perspectives on GIS for representing data, information, knowledge – interplay among reality, database, and map display (ACRL Ind 3.4)</td>
<td>0 Not acceptable</td>
</tr>
<tr>
<td></td>
<td>No familiarity with representing data</td>
<td>Maps represent features of the world</td>
</tr>
<tr>
<td>2</td>
<td>Analytical and communication perspectives on representation</td>
<td>Can not distinguish perspectives</td>
</tr>
<tr>
<td>3</td>
<td>Geographic concept abstraction as relationship among geographic phenomena, object types, and data measurements (ACRL Ind 3.3)</td>
<td>All are the same, no difference is detected</td>
</tr>
<tr>
<td>4</td>
<td>Data sources (ACRL Ind 1.2) primary data sources secondary data sources Census TIGER, WAGDA</td>
<td>All data are the same</td>
</tr>
<tr>
<td>5</td>
<td>Data collection/acquisition/entry approaches, technology, and formats (ACRL Ind 2.1)</td>
<td>Know about one or two formats, but not know why they exist</td>
</tr>
<tr>
<td>6</td>
<td>Data search, compilation, and integration (ACRL Ind 2.2)</td>
<td>Do not understand how data search influences information outcomes</td>
</tr>
<tr>
<td>7</td>
<td>Surveys and coordinate systems for spatial referencing</td>
<td>Surveys and coordinate systems are the same thing</td>
</tr>
<tr>
<td>8</td>
<td>Map projections</td>
<td>Maps are flat; and the earth is not much different</td>
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<tr>
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<td>-------------------------------------------------</td>
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<tr>
<td>9</td>
<td>Map type displays - General/reference - Thematic: Choropleth, Dot, Flow, Proportional Symbol, 2D Surface/Isarithm, 3D Surface and Solids</td>
<td>Not able to understand that maps represent different aspects of the world</td>
</tr>
<tr>
<td>10</td>
<td>Map Layout as Design Graphic Hierarchy Intellectual Hierarchy</td>
<td>Not knowing what map components are used on a map</td>
</tr>
<tr>
<td>11</td>
<td>Symbolization as design Graphic variables and color use</td>
<td>Recognize graphic marks, but unsure of use</td>
</tr>
<tr>
<td>12</td>
<td>Generalization as design Classification, Selection, Simplification, Induction</td>
<td>Not know about generalize in mapping</td>
</tr>
<tr>
<td>13</td>
<td>Visual cognition as map use Cognitive Skills (identify, recognize, understand, knowing, demonstrating, applying)</td>
<td>Unsure why cognition is important in mapping</td>
</tr>
<tr>
<td>14</td>
<td>GIS use as critical thinking (ACRL Ind 1.4) and geospatial problem solving (ACRL Ind 3.1) by individuals, groups, and organizations (ACRL Ind 3.6, 4.1) for problem exploration, planning, risk management, decision making</td>
<td>Unaware that maps can assist people with thinking through geospatial problems</td>
</tr>
<tr>
<td>15</td>
<td>GIS data structures; object types: point, line, polygon, and surface</td>
<td>Confuse data with graphical symbols used to portray data - thinking they are the same thing</td>
</tr>
<tr>
<td>16</td>
<td>GIS data management (ACRL Ind 2.3, 2.4, 2.5)</td>
<td>Data are stored in a computer somehow</td>
</tr>
<tr>
<td>17</td>
<td>GIS data analysis geometric measurement data manipulation spatial analysis</td>
<td>Data goes in a computer and you get output</td>
</tr>
<tr>
<td>18</td>
<td>GIS information visualization</td>
<td>Data is displayed on a screen by a computer</td>
</tr>
<tr>
<td>19</td>
<td>Data quality and consequences of use, including lineage, positional accuracy, attribute accuracy, logical consistency, completeness (ACRL Ind 3.2, 5.3)</td>
<td>Data is all the same good quality</td>
</tr>
<tr>
<td>20</td>
<td>Application case studies focus on sustainable development issues for natural resource, transportation, land cover, land use, zoning, ecosystems, environmental hazards</td>
<td>GIS can be used for a lot of different things, but no specifics come to mind</td>
</tr>
<tr>
<td>21</td>
<td>Project/product presentation (ACRL Ind 4.3)</td>
<td>Free association talk about a project and maps as a presentation</td>
</tr>
<tr>
<td>22</td>
<td>GIS data models and database structures – linking spatial and attribute data</td>
<td>GIS data is just in computer, without knowing different approaches are needed</td>
</tr>
<tr>
<td>23</td>
<td>Database design process - Conceptual (ACRL Ind 1.1), Logical, and Physical design</td>
<td>Someone puts data in a computer somehow</td>
</tr>
<tr>
<td>24</td>
<td>GIS project management - Gaining organizational support through cost and benefit study (ACRL Ind 1.3) - Workgroup management (ACRL Ind 4.2) - Project workflow steps (ACRL Ind 1.4, 3.7) - Milestones and budgeting</td>
<td>Get a bunch of stuff together for a GIS project</td>
</tr>
<tr>
<td>25</td>
<td>GIS implementation and critical evaluations of GIS use in society; community participation, value conflicts (ACRL Ind 3.5, 5.1, 5.2)</td>
<td>Unaware that GIS has an impact on society</td>
</tr>
</tbody>
</table>

Bloom’s Taxonomy of Cognitive Skills
http://illinois.online.uillinois.edu/IONresources/assessment/bloomtaxonomy.html