

Minds On GIS: Encouraging Spatial Thinking in an Introductory GIS Lab

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Typical GIS Labs



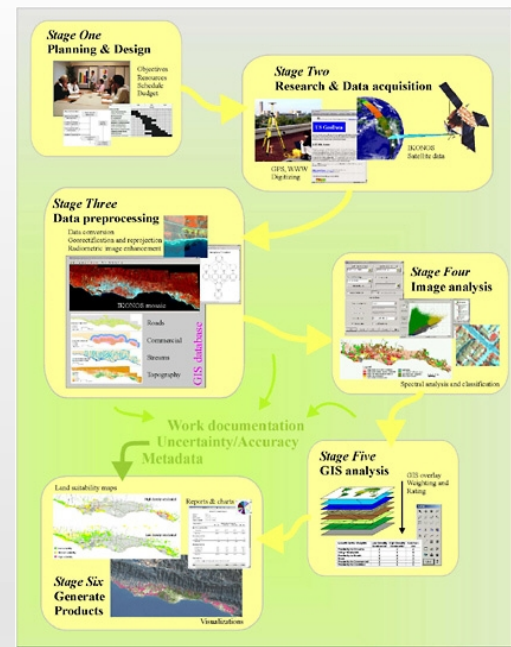
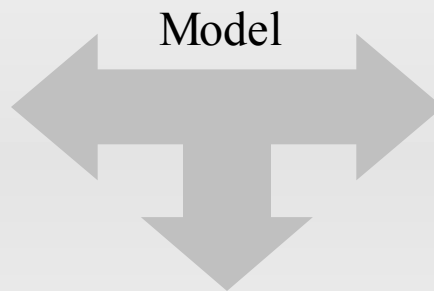
Match the teaching style
with the learning style

Cookbook labs:
Behavioral form of
teaching/learning

Restructure labs to
emphasize a more
constructivist bent

Model

Geographic Information Science & Technology Body of Knowledge	
<small>Edited by David Edrington, 2010 and updated, 2016. Authors: Karim Elmagrabi, David Forster, Lutz Preuss, and Michael Thillig UNIVERSITY CONSORTIUM FOR GEOGRAPHIC INFORMATION SCIENCE</small>	
Analytical Methods AM1 Academic and analytical origins 1.1 Research traditions 1.2 Interdisciplinary approaches AM2 Query operations and query languages 2.1 Query languages 2.2 Query processing AM3 Geographic reasoning 3.1 Reasoning about spatial relationships 3.2 Reasoning about spatial constraints AM4 Basic analytical operations 4.1 Selection 4.2 Aggregation 4.3 Joining AM5 Basic analytical methods 5.1 Point pattern analysis 5.2 Line pattern analysis 5.3 Area pattern analysis 5.4 Network analysis 5.5 Surface analysis AM6 Analysis of surfaces 6.1 Descriptive statistics 6.2 Inferential statistics 6.3 Regression analysis	Cartography and Visualization CV1 History and trends 1.1 History of cartography 1.2 Modern cartography CV2 Visualization techniques 2.1 Map design 2.2 Map production CV3 Principles of map design 3.1 Map design principles 3.2 Map design process CV4 Map production 4.1 Map production process 4.2 Map production tools CV5 Map use and evaluation 5.1 Map use 5.2 Map evaluation
Conceptual Foundations CF1 Philosophical foundations 1.1 Foundations of GIS 1.2 Foundations of GIScience CF2 Cognitive and social foundations 2.1 Cognitive foundations 2.2 Social foundations CF3 Domains of geographic information 3.1 Domains of GIS 3.2 Domains of GIScience	Design Aspects DA1 The scope of GIS/T 1.1 Scope of GIS/T 1.2 Scope of GIS/T DA2 Project definition 2.1 Project definition 2.2 Project definition DA3 Resource planning 3.1 Resource planning 3.2 Resource planning DA4 System implementation 4.1 System implementation 4.2 System implementation
Data Modeling DM1 Basic storage and retrieval structures 1.1 Basic storage and retrieval structures 1.2 Basic storage and retrieval structures DM2 Database management systems 2.1 Database management systems 2.2 Database management systems DM3 Modeling 2D, 3D, uncertain, and temporal phenomena 3.1 Modeling 2D, 3D, uncertain, and temporal phenomena 3.2 Modeling 2D, 3D, uncertain, and temporal phenomena	Design Aspects DA1 The scope of GIS/T 1.1 Scope of GIS/T 1.2 Scope of GIS/T DA2 Project definition 2.1 Project definition 2.2 Project definition DA3 Resource planning 3.1 Resource planning 3.2 Resource planning DA4 System implementation 4.1 System implementation 4.2 System implementation



Question - > Question
 Prediction - > Reflection
 Prediction - > Revision - > Decision

Geographic Information Science & Technology Body of Knowledge

Edited by Frank Ertel, Michael DeGloria, Ann Johnson, Karen Knapp, Ann Taylor Lamb, Brandon Pierce, and Elizabeth Young

UNIVERSITY CONSORTIUM FOR GEOGRAPHIC INFORMATION SCIENCE

Analytical Methods

AM1 Academic and analytical origins

- 1-1 Academic foundations
- 1-2 Analytical approaches

AM2 Query operations and query languages

- 2-1 SQL
- 2-2 Standard Query Language (SQL) and database systems
- 2-3 Spatial queries

AM3 Geometric measures

- 3-1 Distance and length
- 3-2 Area
- 3-3 Slope
- 3-4 Area
- 3-5 Perimeter and distance decay
- 3-6 Adjacency and connectivity

AM4 Basic analytical operations

- 4-1 Buffer
- 4-2 Overlay
- 4-3 Neighborhood
- 4-4 Map algebra

AM5 Basic analytical methods

- 5-1 Point pattern analysis
- 5-2 Density and density estimation
- 5-3 Spatial cluster analysis
- 5-4 Spatial interaction
- 5-5 Analyzing multi-dimensional datasets
- 5-6 Geographic modeling
- 5-7 Multivariate analysis
- 5-8 Spatial process models

AM6 Analysis of surfaces

- 6-1 Calculating surface derivatives
- 6-2 Interpretation of surfaces
- 6-3 Surface features
- 6-4 Topography
- 6-5 Slope surfaces

AM7 Spatial statistics

- 7-1 Regional statistics
- 7-2 Multivariate processes
- 7-3 The spatial weights matrix
- 7-4 Global measures of spatial association
- 7-5 Local measures of spatial association
- 7-6 Outliers
- 7-7 Bayesian methods

AM8 Geostatistics

- 8-1 Spatial sampling for statistical analysis
- 8-2 Structure of geostatistical spatial models
- 8-3 Data management modeling
- 8-4 Kriging and co-kriging
- 8-5 Spatial models

AM9 Spatial regression and econometrics

- 9-1 Interpretation of spatial econometrics
- 9-2 Spatial econometric models
- 9-3 Spatial modeling
- 9-4 Spatial regression and diagnosticity
- 9-5 Weighted Least Squares (WLS)

AM10 Data Mining

- 10-1 Definition of large spatial datasets
- 10-2 Data mining approaches
- 10-3 Knowledge discovery
- 10-4 Feature recognition and modeling

AM11 Network analysis

- 11-1 Network definition
- 11-2 Graph-theoretic (topological) measures
- 11-3 Network shortest paths
- 11-4 Flow modeling
- 11-5 The Traveling Salesman Problem
- 11-6 Other classic network problems
- 11-7 Accessibility modeling

AM12 Optimization and location-allocation modeling

- 12-1 Operations research modeling and systems modeling overview
- 12-2 Linear programming
- 12-3 Integer programming
- 12-4 Location-allocation modeling and

Conceptual Foundations

CF1 Philosophical foundations

- 1-1 Philosophy and ontology
- 1-2 Epistemology
- 1-3 Methodological perspectives

CF2 Cognitive and social foundations

- 2-1 Theoretical foundations of geographic phenomena
- 2-2 From a map to GIS
- 2-3 Geography as a Discipline (GI-D)
- 2-4 From GIS to GIScience
- 2-5 Cognitive and social geographic information science
- 2-6 Cultural software
- 2-7 Software science

CF3 Domains of geographic information

- 3-1 Space
- 3-2 Time
- 3-3 Knowledge between space and time
- 3-4 Properties

CF4 Elements of geographic information

- 4-1 Objects and features
- 4-2 Events and processes
- 4-3 Relations and links
- 4-4 Organizational models

CF5 Relationships

- 5-1 Categories
- 5-2 Hierarchical, structural relationships
- 5-3 Dimensional relationships: things, phenomena
- 5-4 Topological relationships
- 5-5 Dimensional relationships: distance and direction
- 5-6 Spatial distributions
- 5-7 Regions
- 5-8 Spatial integration

CF6 Imperfections in geographic information

- 6-1 Systems
- 6-2 Methodological models of representation: maps, maps and digital maps
- 6-3 Spatial model quality
- 6-4 Methodological models of uncertainty: probability and distance

Cartography and Visualization

CV1 History and trends

- 1-1 History of cartography
- 1-2 Technological innovations

CV2 Data visualization

- 2-1 Visual materials for mapping
- 2-2 Visualization: visualization, cartography, and urban systems
- 2-3 Perspective as a visual design device

CV3 Principles of map design

- 3-1 Map design fundamentals
- 3-2 Data visualization of spatialization
- 3-3 Visual design and communication
- 3-4 Designing for cartography and visualization

CV4 Map production

- 4-1 Cartographic design
- 4-2 Map production
- 4-3 Map reproduction

CV5 Map use and evaluation

- 5-1 User-centered design
- 5-2 Map reading
- 5-3 Map interpretation
- 5-4 Evaluation and testing
- 5-5 Impact of usability

Design Aspects

DA1 The scope of GIS&T system design

- 1-1 Design methods to represent information
- 1-2 Representability of remote data, attributes, metadata
- 1-3 Representability of GIS&T applications
- 1-4 The scope of GIS&T design
- 1-5 The process of GIS&T design

DA2 Project definition

- 2-1 Problem definition
- 2-2 Planning for design
- 2-3 Application user requirements
- 2-4 Requirements analysis
- 2-5 Goals, policies, and related needs

DA3 Resource planning

- 3-1 Feasibility analysis
- 3-2 Software options
- 3-3 Data costs
- 3-4 Labor and management
- 3-5 System, facilities and equipment
- 3-6 Staffing

DA4 Database design

- 4-1 Modeling needs
- 4-2 Development alternatives for geographic applications
- 4-3 Object-oriented Software Engineering (OOSE) tools

DA5 Application design

- 5-1 User interface
- 5-2 Development alternatives for geographic applications
- 5-3 User-centered design
- 5-4 System architecture

DA6 System implementation

- 6-1 Design implementation
- 6-2 User requirements
- 6-3 System architecture
- 6-4 System architecture

DA7 System evaluation

- 7-1 User requirements
- 7-2 System architecture
- 7-3 System architecture
- 7-4 System architecture

DA8 System evaluation

- 8-1 User requirements
- 8-2 System architecture
- 8-3 System architecture
- 8-4 System architecture

DA9 System evaluation

- 9-1 User requirements
- 9-2 System architecture
- 9-3 System architecture
- 9-4 System architecture

Data Modeling

DM1 Basic storage and retrieval structures

- 1-1 Basic data structures
- 1-2 Data storage structures
- 1-3 Retrieval structures

DM2 Database management systems

- 2-1 Overview of GIS&T and GIS
- 2-2 Database systems
- 2-3 Data modeling
- 2-4 Structure of the relational model

DM3 Transaction data models

- 3-1 Overview
- 3-2 Relational models of transactions: theory, maps and digital maps
- 3-3 Relational models of uncertainty: probability and distance
- 3-4 Relational models of uncertainty: probability and distance
- 3-5 Relational models of uncertainty: probability and distance

DM4 Vector and object data models

- 4-1 Relational models
- 4-2 Relational models of uncertainty: probability and distance
- 4-3 Relational models of uncertainty: probability and distance
- 4-4 Relational models of uncertainty: probability and distance
- 4-5 Relational models of uncertainty: probability and distance

DM5 Modeling 3D, uncertain, and temporal phenomena

- 5-1 System architecture
- 5-2 Modeling uncertainty
- 5-3 Modeling three-dimensional entities

“The Body of Knowledge is a resource for specifying course content, for designing educational activities, and for assessing courses’ effectiveness in achieving intended outcomes.” – BOK

10 Knowledge Areas

73 Units

330+ Topics

<http://www.aag.org/bok/>

CF. Conceptual Foundations
CF1 Philosophical foundations
CF2 Domains of geographic information
CF3 Cognitive foundations
CF4 Geographic foundations
CF5 Social foundations
CF6 Theoretical models
CF7 Imperfections in geographic information

CV. Cartography and Visualization
CV1 History and trends
CV2 Data considerations for cartography and visualization
CV3 Principles of map design
CV4 Graphic representation techniques
CV5 Map production
CV6 Map use and evaluation

DA. Data Analysis
DA1 Academic foundations of geospatial data analysis
DA2 Query operations and query languages
DA3 Geometric operations on spatial objects
DA4 Modeling relationships and patterns
DA5 Analysis of surfaces
DA6 Spatial statistics
DA7 Geostatistics
DA8 Spatial econometrics
DA9 Data mining
DA10 Network analysis
DA11 Operations research

DE. Design Aspects
DE1 Applications as models
DE2 Project definition
DE3 Resource planning
DE4 Database design
DE5 Analytic model design
DE6 Application design
DE7 System implementation

DM. Data Modeling
DM1 Basic storage and retrieval structures
DM2 DBMS and the relational model
DM3 Tessellation data models
DM4 Vector data models
DM5 Multiple scale representation/models
DM6 Object (oriented) and object based models
DM7 Temporal representation/models
DM8 Metadata
DM9 Data exchange and operability

DN. Data Manipulation
DN1 Data format conversion
DN2 Generalization and aggregation
DN3 Transaction management of geospatial data

GC. Geocomputation
GC1 History and trends in geocomputation
GC2 Uncertainty
GC3 Computational aspects and neurocomputing
GC4 Fuzzy sets
GC5 Cellular automata (CA) models
GC6 Heuristics
GC7 Genetic algorithms
GC8 Agent-based models
GC9 Activity analysis

GD. Geospatial Data
GD1 Earth geometry
GD2 Land partitioning systems
GD3 Coordinate systems
GD4 Datums
GD5 Map projections
GD6 Data quality
GD7 Land surveying and GPS
GD8 Digitizing
GD9 Field data collection
GD10 Aerial surveys and photogrammetry
GD11 Satellite and shipboard remote sensing
GD12 Data standards and infrastructures

GS. GI S&T and Society
GS1 Legal aspects of GI S&T
GS2 Economic aspects of GI S&T
GS3 Public use of geospatial information
GS4 Control of geospatial information
GS5 Dissemination of geospatial information
GS6 Coordinating organizations
GS7 Ethical aspects of GI S&T
GS8 Critical GIS

OI. Organizational and Institutional Aspects
OI1 Historical and future trends in organizational and institutional aspects
OI2 Managing the GI system operations and infrastructure
OI3 Organizational structures and procedures
OI4 GI S&T workforce themes
OI5 Institutional aspects
OI6 Coordinating organizations

Example Questions:

Knowledge Area - Conceptual Foundations

Unit CF3 Domains of geographic information (Core Unit)

Topic CF3-1 Space

Define the four basic dimensions or shapes used to describe spatial objects (i.e., points, lines, regions, volumes)

Differentiate between absolute and relative descriptions of location

Differentiate between common-sense, Cartesian/metric, relational, relativistic, phenomenological, social constructivist, and other theories of the nature of space

Discuss the contributions that different perspectives on the nature of space bring to an understanding of geographic phenomenon

Justify the discrepancies between the nature of locations in the real world and representations thereof (e.g., towns as points)

Select appropriate spatial metaphors and models of phenomena to be represented in GIS

Develop methods for representing non-Cartesian models of space in GIS

Discuss the advantages and disadvantages of the use of Cartesian/metric space as a basis for GIS and related technologies

Key readings - Conceptual Foundations

Berry, B. J. L. (1964). Approaches to regional analysis: a synthesis. *Annals of the Association of American Geographers*, 54, 2-11. (Units CF3-CF4)

Couclelis, H. (1992). People manipulate objects (but cultivate fields): Beyond the raster-vector debate in GIS. In A. U. Frank, I. Campari, & U. Formentini, (Eds.), *Theories and methods of spatio-temporal reasoning in geographic space*. (65-77). Berlin: Springer Verlag (Unit CF4)

Egenhofer, M. J. (1991). Reasoning about binary topological relations. *Lecture Notes in Computer Science*, 525, 144-160. (Unit CF5)

Frank, A. (1998). Different types of "times" in GIS, in M. Egenhofer & R. Golledge (Eds.), *Spatial and temporal reasoning in geographic information systems* (40-62). New York: Oxford University Press. (Unit CF3)

Hägerstrand, T. (1970). What about people in regional science? *Papers, Regional Science Association*, 24, 1-21. (Units CF3, CF4)

Lakoff, G. (1987). *Women, fire, and dangerous things*. Chicago: University of Chicago Press. (Units CF1, CF2)

Egenhofer, M., & Mark, D. M. (1995). Naive geography. In A. Frank & W. Kuhn (Eds.), *Lecture*

Mark, D. M., & Freundschuh, S. M. (1995). Spatial concepts and cognitive models for geographic information use. In T. L. Nyerges, D. M. Mark, R. Laurini, & M. Egenhofer (Eds.), *Cognitive aspects of human-computer interaction for geographic information systems*. (21-28). Dordrecht: Kluwer Academic Publishers: (Unit CF2)

Mennis, J. L., Peuquet, D. J., & Qian, L. (2000). A conceptual framework for incorporating cognitive principles into geographical database representation. *International Journal of Geographical Information Science*, 14, 501-520. (Units CF2, CF4)

Teaching Format

Question-Question

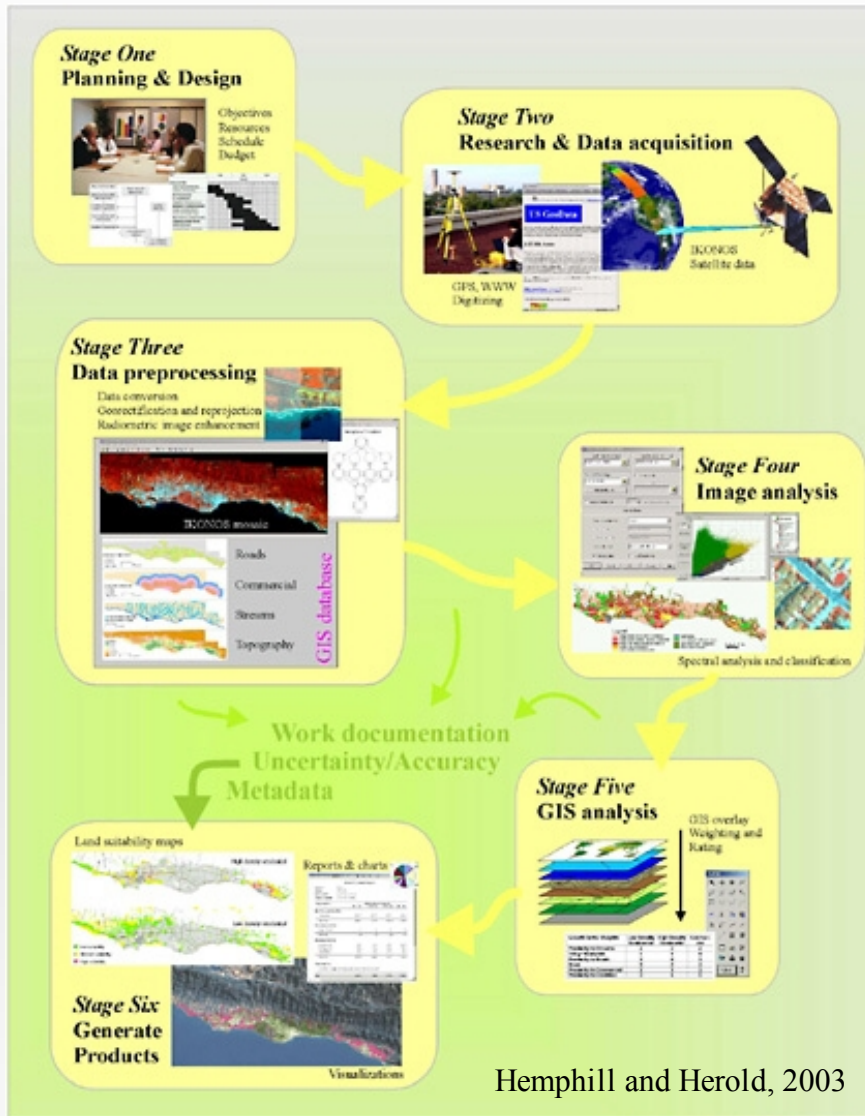
Ask it early!

Prediction-Reflection

Self-assessment

Prediction-Revision-Decision

Policy /problem solving



GIS Research Model

Integrate stages into labs from the beginning

Emphasize the process

Multistage analysis in a pictorially based GIS

What's Next?

Consult with GIS faculty.

Make available online.

Take cognition and learning courses.

Submit as student paper to 2008 UCGIS Summer Assembly

Publication?

Other projects:

Create GIS workshop for grad students.

Design a GIS course for pre-service social science teachers.



Thank You

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