Update on the UCGIS Model Curricula Project

*Prepared by Karen K. Kemp on behalf of the UCGIS Model Curricula Task Force**

Graduates of many existing academic programs find themselves ill-equipped when they seek employment in one of the many public and private sector activities making substantial use of geographic information systems (GIS). Among the difficulties that they encounter are: inadequate knowledge of the critical computer science/information technology basis of GIS; a weak understanding of the special characteristics of spatial data; insufficient knowledge pertaining to both the current theoretical and practical status of spatial analysis and the capabilities of the technology available to implement spatial analysis approaches; and insufficient training in identification of the spatial components of problems and in the specification of potential solutions to these problems.

The University Consortium for Geographic Information Science (UCGIS), a group of more than 60 colleges and universities, public agencies and private sector firms, is undertaking to address this problem through the development of a flexible, broadly based undergraduate curricula in Geographic Information Science and Technology (GI S&T). Curriculum, as used in this document, refers to a 4-year course of study consisting of specified major and minor courses, together with specified prerequisites, general education courses, and electives leading to one of the standard undergraduate degrees.

Origin of the Model Curricula Project

The UCGIS Model Curricula Project arose out of the UCGIS Education Challenges identified at the 1997 UCGIS Summer Assembly in Bar Harbor, Maine. One of the challenges, "Alternative Designs for Curriculum Content & Evaluation," recognized that "as the development and use of GIS continue to grow, it is increasingly important for educators to deliver a proper foundation in GIScience. However, there are many different education constituencies and each has different educational needs. Many GIScience [geographic information science] curricula have been developed over the last 20 years using a one-size-fits-all approach. It is time to consider the various demands of GIS workplaces and the needs of different types of students. … Therefore, improving GIScience education requires the specification and assessment of curricula for a wide range of student constituencies" (Kemp and Wright 1997). The UCGIS Executive was pleased when Prof. Duane Marble, upon his advancement to the status of Emeritus Professor at The Ohio State University, volunteered to lead an effort to address these issues. A Task Force was soon formed to undertake related tasks. Membership is listed at the conclusion of this report.

The Task Force on the Model GI S&T Curricula is an activity of the Education Committee of the UCGIS. The Task Force, acting through its Steering Committee, is engaged in the development of a flexible, multi-path set of undergraduate Model Curricula. Among the goals of the Model Curricula are to significantly increase both the technical depth (especially in the areas of computer science, information technology and spatial analysis) and the interdisciplinary breadth of graduates from programs with explicit GI S&T components. Another major goal involves the improvement of graduate's ability to identify problems with a spatial or spatial-temporal context and to apply existing GI S&T concepts and tools to their solution.

The Domain of the GI S&T Body of Knowledge

In a rapidly developing interdisciplinary area such as Geographic Information Science & Technology, it is difficult to precisely identify its boundaries. What should be included? What should be excluded? The responses to these questions most often reflect individual disciplinary views, but in order to remove the serious gaps and overlaps that currently characterize undergraduate education in the GI S&T realm, we must develop, as a minimum, a sharp and intuitive view of what is under discussion.

The domain that is to be spanned by the GI S&T Body of Knowledge is initially defined by a three-component model of GI S&T: Geographic Information Science, Geographic Information Technology, and Utilization of Geographic Information Science & Technology. Where do we draw the line between the GI S&T Body of Knowledge and the rest of human understanding? From a pragmatic point of view, this will be accomplished as the GI S&T Body of Knowledge is iteratively developed. Since GI S&T is an interdisciplinary collection of concepts, tools, and data from many spatially oriented disciplines, for each discipline we may expect to see some inclusions and some exclusions. For example, the general body of Statistics would be excluded but spatial statistics would be included. This does not mean that the former is not relevant nor that knowledge in this area is not a prerequisite to some GI S&T activities.

The intent of the Model Curricula effort is not to define a new GI S&T discipline, but rather to define a common interdisciplinary area that will be capable of significantly augmenting each of the existing disciplines. To accomplish this, we must recognize that broadening the student's knowledge of critical interdisciplinary topics as well as increasing the overall level of technical competence represent primary concerns.

Specific student outcomes with respect to GI S&T have been generalized to permit the curriculum to chiefly address a more limited number of closely related outcomes. These include:

- the routine application of GI S&T within a specific disciplinary area (e.g., a student planning an operational career in the forest industry),
- the development of new GI S&T applications within one or more closely related disciplinary areas (e.g., a hydrologist whose professional concern will be with non-routine and new applications of GI S&T in that area),
- the advancement of GI S&T related scientific knowledge within a discipline (e.g., a student intending to seek an advanced degree in geography with a specialty in locational analysis), or
- the development, construction, and testing of new geographic information technology (e.g., a student in computer science or geodetic science who intends to seek a career in GI S&T software development).

Attainment of any of these generalized outcomes requires the acquisition of a specific set of skills and concepts – some relating to the student's discipline of choice and others drawn from the broader interdisciplinary area of GI S&T. Associated with each generalized outcome will be a path that defines the appropriate traversal of a curriculum that is needed to attain the specified outcome. When completed, the Model Curricula will identify and enumerate a number of these paths. It is anticipated that the disciplinary content of those paths primarily associated with GI S&T applications will be adjusted by the disciplines involved, so as to more closely meet the special needs of each discipline.

Defining the GI S&T Body of Knowledge

After substantial discussion, the Task Force agreed to adopt a modified version of the highly successful curriculum development methodology that has been utilized for several decades in the areas of computer science (IEEE Computer Society and Association for Computing Machinery 2001), information technology (Association for Computing Machinery, Association for Information Systems, and Association of Information Technology Professionals 1997), and project management (Project Management Institute 2000). This top-down design approach involves the definition of the GI S&T Body of Knowledge (BoK) and its subsequent decomposition into the critical components of various outcome-based paths that will characterize the final form of the Model Curricula.

The knowledge areas will be broken down into units (representing individual thematic modules). Each unit will then be further subdivided into a set of topics representing the lowest level of the hierarchy which will be used as the building blocks to construct model courses. The same topics may appear in different courses depending on the competency levels required. The Task Force will seek to identify a minimal GI S&T core consisting of those units for which there is a broad consensus that the corresponding material is essential to everyone studying beyond the General Education level who is seeking an undergraduate degree with an explicit GI S&T component.

The concerns of the Task Force extend beyond identification of the intellectual content of the Model Curricula. It must also address the significant implementation and infrastructure questions that surround it. A subsequent and closely related curriculum activity involves the need to specifically identify those components of supporting curricula (e.g., those in computer science, geography, mathematics and statistics) that are needed to sustain the GI S&T curriculum.

Other disciplines who have utilized the BoK approach through a number of evolutionary revisions have found that it provides a strong foundation upon which to incorporate scientific, technical, and application knowledge advancements. In GI S&T, no definition of a relevant BoK existed when the Task Force began its work. Creating an initial draft of a GI S&T BoK has been a challenging task. Thus, the Task Force is committed to the widespread public review of its work in progress that must involve as many components of the GI S&T community as possible, including users in industry and government as well as academia.

The Draft GI S&T Body of Knowledge

The Task Force has undertaken several internal iterations of a Body of Knowledge that have led to the present public "Initial Draft" of the GI S&T Body of Knowledge. The Task Force has been materially assisted in deliberations by a number of professionals, mostly academics, who have been kind enough to provide input and comments. Following the UCGIS 2002 Summer Assembly in Athens, Georgia, the Task Force agreed upon the following initial list of knowledge areas.

The 14 GI S&T Knowledge Areas

1. Conceptualization of space
2. Formalizing space conceptions
3. Spatial data models and data structures
4. Design aspects
5. Spatial data acquisition, sources and standards
6. Spatial data manipulation
7. Exploratory spatial data analysis
8. Confirmatory spatial analysis
9. Computational geography (geocomputation)
10. Conceptualizing spatial visualizations and presentations
11. Building spatial visualizations and presentations
12. Evaluating spatial visualizations and presentations
13. Organizational and institutional aspects
14. Professional, social, and legal aspects

Note that the Task Force defines the terms "space" and "spatial" in this context to include reference to "space-time" and "spatial-temporal."

In addition to the knowledge areas, the Task Force recognizes that there are some very basic concepts common to many of the areas. Their significance is in their importance to all knowledge areas. These Cross-Cutting Themes exist in parallel with the knowledge areas. Thus, they will be incorporated into the more detailed specifications of each Knowledge Area as appropriate.

The Nine Cross-Cutting Themes

1. Scale
2. Error and data quality
3. Uncertainty
4. Metadata
5. Interoperability
6. Generalization
7. Quality management
8. History and trends
9. Standards

Status of the Project

The GI S&T Body of Knowledge is rapidly evolving. However, intense interest in the outcome of this project continues to provide momentum to the group and others who are assisting in its development. The current status of this project can be found on the web at www.ucgis.org.

Footnote

* The Task Force includes the Chair Duane Marble (The Ohio State University) and Members Linda Bishoff (GE Smallworld), Aileen Buckley (University of Oregon), Michael DeMers (New Mexico State University), Ann Johnson (ESRI), Farrell Jones (Intergraph), Karen Kemp (University of Redlands), Carolyn Merry (The Ohio State University), Donna Peuquet (The Pennsylvania State University), Jay Sandhu (ESRI), Mandayam Srinivas (California State Polytechnic University-Pomona), Elizabeth Wentz (Arizona State University), and Richard Wright (San Diego State University).

References

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