

# GIS Curricula in China's Higher Education

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## Abstract

The Ministry of Education of P.R.C has been updated the major catalogue of China's higher education and added major of GIS in geographical science since 1997, the major of GIS has been set up in 93 universities and colleges nationwide. The curricular structure and the establishment of core courses are one of the most significant steps in GIS education. This paper, based on a questionnaire and investigation, points out that the curricular structure of GIS is composed of three parts, including general education courses, foundation courses for GIS and GIS courses. Then, the situation of foundation courses for GIS and GIS courses in various universities and colleges is especially discussed and the characteristics of the GIS courses is portrayed. Finally, the paper put forward the tentative program of the core courses setting, which can be utilized as a reference for different universities and colleges to plan their GIS education and the construction of core courses.

## I. INTRODUCTION

The Ministry of Education of P.R.C revised the major catalogue of China's higher education in 1997 and merged or truncated some undergraduate majors in universities and colleges. But the major of GIS was added to the subject of geography. As well as, students majoring in GIS can be granted with the degrees of science or engineering. In recent years, the major of GIS has been rapidly developed. 93 universities and colleges wide across the country, including 15 universities and 33 normal universities and 45 scientific and engineering colleges, have been granted by the Ministry of Education to establish major of GIS.

To improve GIS education, the Chinese association of GIS and Geographic Committee of National Higher Education entrusted the author to send the questionnaire about the situation of GIS education to more than 100 universities and colleges in the first half of 2003. According to the responded information, the plan of GIS education listed on the web site of some universities and colleges and the materials provided by relevant papers of seminar about the education of GIS in August 2003, the author introduces and analyzes the situation of curricular structure and core courses about the major of GIS in Chinese universities and colleges.

## II. CURRICULAR STRUCTURE AND CLASSIFICATION OF GIS COURSES

The curricular structure and core courses of GIS are the central points of the cultivation of GIS specialists and constitution of education criterion, as well as it is the core contents of GIS educational program. The structure of GIS major is composed of general education courses, foundation courses for GIS and GIS courses.

General education courses are required courses assigned by the Ministry of Education or relevant institutes. These courses contain foreign language, physical education, advanced mathematics and fundamentals of computer and so on. Usually, general education courses are imparted by teachers in other schools or departments in universities or colleges. General education courses may not be directly related with GIS, they are essential and imperative to cultivate undergraduates or graduates to be well-rounded persons and to prepare them for higher education.

Foundation courses for GIS are rudimentary courses that are directly related with GIS. The intention of establishing these courses is to help students to make preparation for gaining professional knowledge and skills, and to increase students' adaptability. For students who are majoring in GIS, these courses generally contain three foundations: first, geographic fundamental courses, such as Introduction to Geosciences, Introduction to Physical Geography, Economic Geography, Environmental Ecology, Urban and Regional Science etc.; then computer-oriented courses, such as Introduction to Computing, Programming Language, Algorithms and Data Structures, Computer Graphics, Introduction to DBMS etc.; Finally, fundamental mathematical courses such as Linear Algebra, Discrete Mathematics, Probability and Mathematical Statistics, Quantitative Mathematics, Mathematical Equation etc.. However, here are some people who believe that courses in the third section belongs to the category of general education courses.

The GIS courses are mainly established for undergraduates majoring in GIS. With regard to the importance of these courses, GIS courses can be divided into required courses and elective courses. Required courses refer to courses that must be accomplished by students majoring in GIS. These

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courses are guarantee for cultivating professional elites in GIS. Generally speaking, only a few courses are included in this category. Elective courses are selected according to teaching requirements or students' interest. They are beneficial for students to broaden their professional kin, increase their ability of applying GIS to other fields and to make preparation for their study competence about specific areas. According to collected questionnaire information, foundation courses for GIS in universities and colleges are their main courses. In addition, elective courses contain several major technical courses and experimental courses.

All these courses mentioned above constitute current major curricular structure of GIS in Chinese universities and colleges.

### III. THE STATUS OF GIS COURSES SETTINGS

GIS courses settings generally refers to assigned plan made by universities and colleges about the education of GIS. It contains several aspects: which courses should be established, which school year or term the courses will be given, how many periods should be given to the courses and how the contents of course setting can be reflected through educational plans.

To gain better understanding about the status quo of curricular setting of GIS in various universities and colleges, Tables 1, 2 and 3 are listed the situations of major courses of GIS in terms of the order: universities, normal universities and scientific and engineering colleges. From Table 1 to Table 3, there are only listed part of foundation courses for GIS and GIS courses, whereas not any general education courses and part of mathematical subjects are included. To be more specific, these forms only list main foundation courses for GIS and GIS courses and all of those courses may be classified through four categories: geography, computer science, RS and Photogrammetry and GIS.

Following characteristics of GIS course settings may be concluded from Tables 1, 2 and 3.

#### Setup a series of GIS related courses

It is found from the tables that departments of GIS in most universities, normal universities and scientific and engineering colleges have opened courses of *Principle of GIS* (or *Introduction to GIS*), *Design and Development of GIS* (or *Design of GIS Software*), *Application of GIS* etc., while parts of those departments have opened *GIS engineering*, *Web-GIS* and so forth. It shows that the recognition of abovementioned courses and special emphasis of China's university and colleges on the settings of courses relating to *Principle and Method of GIS*, *Design and Development Technology*, *Technology Application as well as Engineering Management and Implementation*.

#### Remote sensing related courses have been valued

Departments of GIS in many universities attach much importance to the opening of courses relating to remote sensing (RS). For example, most universities and colleges has opened RS courses for students specializing in GIS such as Introduction to RS (Fundamentals of RS), RS Image Processing (Digital Image Processing), while some of them have opened such courses as Application of RS Technology, Photogrammetry and Image Interpretation and Analysis. It demonstrates that the GIS major in most universities and colleges agree on the importance of RS.

#### GIS course settings in different universities and colleges reveals their own characteristics and advantages

Comparing with the curricular settings in those universities and colleges, we can find that the settings of the foundation courses for GIS have specific characteristics. For example, universities and colleges characterized with science opened more courses related to geography and cartography in the setting of the foundation courses for GIS, while those relying on engineering have more courses concerning with geodesy and charting. With regard to the course settings, the colleges or departments qualified with geography background, generally put more emphasis on geography in the major of GIS; some of them having advantages in geodesy, generally emphasis on geodesy. Similarly, the courses about computer in the major of GIS take precedence over other courses in colleges or departments dominating in computer and information science. Of course, characteristics and advantages is not only completely decided by the educational backgrounds and professors in the major of GIS, but also is relevant to these factors, such as educational goals to cultivate professional persons and the social need for these persons (for example, knowledge structure and the quality of elites).

#### Most of the universities and colleges have not opened the course related to E-Government, Management of Logistics, as well as Web-GIS, which are closely relevant to GIS and are urgently needed by the society as a whole

Which foundation courses for GIS and GIS courses should be established in the settings of GIS educational plan is not only relevant to the importance of these courses in the major of GIS, but is also influenced by appropriate teachers imparting them and other factors, such as the quality of students and the educational and experimental equipment.

### IV. TENTATIVE PROGRAM FOR CORE COURSES

There is no clear definition of what are the core courses for GIS major. Some universities regard required courses for GIS as the core courses, while others suggest that both important foundation courses for GIS and GIS courses should be included in the core courses. Since there is no clear principle for

**Table 1.** GIS Course Settings for Undergraduates in Part of Universities in China (see Appendix for abbreviations)

University	Dept. of Spatial Science & Technology (Institute of RS & GIS), Peking University	Dept. of Geographic Information Science, College of Resource and Environmental Science, Wuhuan	Dept. of RS and Geographic Information Engineering, College of Geographic Science and Planning, Zhongshan	College of Geography and Environment, Zhongnan University	College of Environment and Planning, Henan University	College of City and Environment, Xibei University	Dept. of Region and Resource, College of Resource Environment and Geosciences, Yunnan University
Intro. to Geosci.	√						
Geodesy		√	√	√	√	√	
Geomorphology		√					
Intro. to Geographic Sci.	√						
Geology							√
Quantitative Geog.					√		
Physical Geog.		√		√	√		√
Human Geog.				√	√		
Economic Geog.				√	√		√
Ecological and Environmental Sci.	√				√		
Cartology		√	√	√	√	√	
Computer-based Mapping					√	√	
Resources and Environmental Engineering					√		
Urban & Regional Sci.	√						
Land Use and Planning							√
Natural Resources					√		
Math. Model of Geo.	√						
Algorithm and Data Structures	√	√	√	√	√		
Programming Language	√			√	√		
Introduction to Computer	√						
Computer Graphics	√	√	√				
Intro. to Database	√	√	√	√	√		√
Software Engineering	√						
Geodesy and Cartology	√						√
Intro. to RS	√	√	√	√	√	√	
RS Image Pro.	√		√		√	√	
RS Image Pro. Experiment	√						
Princl. and Appl. of RS				√		√	
RS of Resource & Environment				√			
Intro. Navi. & Commu.	√						
Intro. to GIS	√		√	√		√	
Princl. of GIS		√			√		√
GIS Appl. and Design	√	√	√	√		√	
GIS Appl.				√			
Urban GIS			√				√
Geographic Coding and Spatial GIS				√			
GIS Engineering	√						
DEM	√						
GIS Appl. and Development					√		√
GIS Special Analysis				√	√	√	
Digital Earth	√						
Network and Web-GIS	√			√			
Photogrammetry		√				√	
Spatial DBMS		√					
OS			√				
3S System				√			
Intro. to Systematic Sci.					√		
Network Technology					√	√	
Princl. and Appl. of GPS					√		
Geog. Model & Spatial Analysis					√		
Electrical Publishing System						√	
Info. Theory						√	

**Table 2.** GIS Course Settings for Undergraduates in Part of Normal Universities in China (see Appendix for abbreviations)

University	Department of GIS in College of Geosciences, Nanjing Normal University	Department of Geography in College of Resource and Environment, East China Normal University	Department of Resource and Environment, Beijing Normal University	Department of Geographic Information Engineering in College of Resource and Environmental Science, Hunan Normal University
Courses				
Intro. to Geosci.		√		
Geology& Geomorphology		√	√	
Meteorology and Climatology		√	√	
Soil and Vegetation System		√	√	
Hydrology and Water Resources		√		
Physical Geog.	√	√		√
Human Geog.		√	√	
Economic Geog.			√	
Ecology			√	
Regional Science		√		
Urban Geography		√		
Urban& Regional Planning	√			√
Intro. Resources and Environmental Sci.		√	√	
Chinese Physical Geog.		√		
Chinese Economic Geog.		√		
Quantitative Geog. and Geographic Modeling	√			
Geographic Literature and Writing			√	
Programming Language		√		√
Computer Visualization Language	√			
Object Oriented Programming				√
Data Structures	√			
Computing Methods		√	√	
Intro. DBMS	√		√	
Computer Graphics	√		√	√
Computer Based Mapping		√		√
Multimedia Technology	√			
Artificial Intelligence and Expert System	√			
Cartology and Geodesy	√			√
Intro. to RS	√	√	√	√
RS of Resources and Environment			√	
RS Image Processing	√	√	√	√
Understanding and Analysis of RS Image	√		√	
GPS	√			√
Quantitative RS			√	
Intro. to GIS	√	√	√	√
Application of GIS	√			
Princl. of Special DBMS				√
GIS Analysis			√	
DEM			√	
Regional & Environmental Modeling		√		
GIS Engineering & design		√		
3S Application			√	

**Table 3.** GIS Course Settings for Undergraduates in Part of Scientific and Engineering Colleges in China (see Appendix for abbreviations)

University Courses	College of Information Engineering, Chinese Geosciences University	Department of Measurement and Country Land Information, Tongji University	Department of Geographical Information Science, College of Water Resource, Hehai University	College of Environment & Measurement, University of Mining and Technology	College of Resource and Environment, Hefei Technical University	Department of Measurement Science, Taiyuan Technological University
Intro. to Geo-science					√	
Physical Geography	√	√	√	√	√	√
Economic Geography			√	√	√	√
Human Geography		√	√			
Military Geography						
Chinese Geography			√			
Cartology	√	√	√	√		√
Geodesy		√	√	√		
Quantitative Geography						
Special Analysis		√		√		√
Intro. to Environmental Science					√	
Urban Geography						√
Intro. to Digital City						
Cadastral Administration, Resource and Environmental Surveying						
Subject Mapping						
Computer Based Mapping						√
Intro. to computer						
Programming Language			√	√		√
Computer Graphics	√			√	√	
Operating System	√					
Network Tecknology					√	
CAD						√
Multimedia Technology				√		
VRML Technology				√		
Software Engineering					√	
Photogrammetry			√	√		√
Photogrammetry and RS		√				
Geodesy and GPS					√	
Intro. to RS			√	√	√	√
RS of Resources and Environment						
RS Image Processing	√	√	√	√		
RS Mapping						
Princl. & Appl. of GPS		√	√	√		
Programming Language						
Computer Visualization Language						
Object Oriented Programming						
Data Structures	√		√	√	√	
Computing Methods						
Intro. DBMS	√		√	√	√	√
Spatial Data Collecting And Quality Control		√				√
Intro. to Geo-information Sci.	√		√			
Special Information Sci.		√				
Intro. to GIS	√		√	√	√	√
GIS Design& Development	√	√	√	√	√	√
GIS Software Engineering				√		
Special Analysis and Model (or DEM)		√				
Application of GIS						
Special Database System	√			√		
Network and Web-GIS				√		
Land Information Science		√				
3S Application						
Decision-Making System						

**Table 3. (To be continued)**

University Courses	Department of Measurement Engineering, Xi'an Technologica University	Department of Measurement Engineering, Beijing College of Civil Engineering and Architecture	Department of City and Environment, University of Science and Technology of Suzhou	Department of Measurement, East China College of Technology	Department of Measuremen,Navy College of Naval Ships of Dalian
Intro. to Geoscience					
Physical Geography	√	√		√	
Economic Geography	√	√			
Human Geography	√				
Military Geography					√
China Geography					
Cartology	√	√		√	√
Geodesy	√				
Quantitative Geography Special Analysis			√		
Intro. to Environmental Science					
Urban Geography					
Intro. to Digital City	√		√		
Land Management, Resource and Environmental Surveying	√				
Digital Chart					√
Computer Based Mapping				√	√
Intro. to computer Programming Language			√		
Computer Graphics		√			
Operating System					
Network Tecknology		√			
CAD					
Multimedia Technology					
VRML Technology					
Software Engineering			√		
Photogrammetry	√	√	√		
Photogrammetry and RS					
Geodesy and GPS	√				
Intro. to RS	√	√		√	
RS of Resources and Environment			√		
RS Image Processing	√	√			
RS Mapping					
Princl. & Appl. of GPS	√		√		
Programming Language Computer Visualization Language					
Object Oriented Programming					
Data Structures	√			√	
Computing Methods					
Intro. DBMS		√		√	
Spatial Data Collecting And Quality Control					
Intro. to Geo-information Sci. Special Information Sci.					
Intro. to GIS	√	√	√	√	√
GIS Design& Development	√	√	√	√	
GIS Software Engineering	√	√		√	
Special Analysis and Model (or DEM)	√		√	√	
Application of GIS			√		√
Special Database System	√		√	√	
Network and Web-GIS	√				
Land Information Science	√				
3S Application			√		
Decision-Making System	√		√		

this definition, not all people hold the same opinion about the content of the concept of core courses. I believe, The purpose of the establishment of major courses for GIS is to cultivate experts in GIS, so a set of scientific core courses will make students majoring in GIS versed in basic theories, basic knowledge and basic skills in GIS and remote sensing, thus making GIS graduates' expertise and knowledge structure satisfy the demand of social progress, economic development and national defense safety. These are the principle for the arrangement of core courses for GIS major.

There are three principles for course arrangement:

**(1) Importance and Uniqueness.** The arrangement of core courses for GIS major is significant to help students master the basic theories, basic knowledge and basic skills in this field. Furthermore, this set of core courses system is different from core courses in other majors because it is established only for GIS major. Through studying those core courses, students are expected to obtain the basic theories, basic knowledge and basic skills systematically in GIS and remote sensing and grow into specialists in GIS gradually.

**(2) Scientificity and Prospect.** It is crucial for the arrangement of core courses to satisfy the demand of economic developments and social progress and adapt to social needs for GIS experts in near future. Accordingly, core course should be designed to not only attach much importance to close combination among theories, methods and applied courses, but also be linked up scientific and systematic. Besides, it is required that the arrangement of core courses should reflect latest research result in this field and keep up with the rapid development in geographic information system and remote sensing technology. In a nutshell, the arrangement of courses should vision the future.

**(3) Fewness in the number of core courses and proficiency in the courses contents.** The number of core courses should be limited and no more than 10 in principle. Proficiency is required in content and it is equally paramount in theory and practice. Insisting on few but precise core courses is conducive to the consistence of core courses in various universities and to the comparativeness in the cultivation of GIS experts. Of course, the requirement of few but precise core courses does not exclude the possibility that departments of GIS in diverse universities develop their own characteristics and advantages or increase to open characteristic lessons and technical lessons aiming at the social demand. On the contrary, sticking to the principle of few but precise core courses will facilitate the arrangement of characteristic lessons with special features in respective universities according to their own peculiarity in GIS major.

According to the principles above, given the inherent connection of each course, a tentative scheme of core course arrangement is propounded as follows.

- Core courses in GIS major are grouped in two: one is

concerning RS and Photogrammetry, the other GIS.

- Core courses regarding Remote Sensing and Photogrammetry may include Fundamentals of RS (Introduction to RS), RS Image Processing and Analyzing and Application of RS image.
- Core courses regarding GIS suggest containing Principle and Methods of GIS, Design and Development of GIS, GIS Engineering and GIS Application.

For discussion, syllabus of each core course is concentrated as follows:

- The course of Fundamentals of RS (Introduction to RS) refers to the basic conception of RS, the basics of RS physics, mechanism of RS imaging as well as the feature of image, the method of interpreting RS images, computer-based RS Image Interpreting and Quantitative RS, etc.
- The course of RS Image Processing refers to Introduction of the optical process of RS image, image transformation, image enhancement, image geometrical coordination, color synthesis and image fusion, model computation of RS image, image classification, etc.
- The course of Analysis and Application of RS image refers to the feature of RS image, RS Information Extraction, Analysis of RS image, Application of RS image in various fields (Urban RS, Geologic RS, agricultural RS, etc)
- The course of Principle and Methods of GIS refers to the basic principle of GIS, data model and data structure of GIS, GIS system framework and its main functions, GIS spatial analysis model, application methods of GIS, etc.
- The Course of Design and Development of GIS refers to system analysis of GIS, the expression and storage of spatial data, GIS general design and particular design, the development method of GIS, the development technology of major models, re-development of GIS.
- The Course of GIS engineering refers to summarization of GIS engineering, design of GIS engineering, practice of GIS engineering, management of GIS engineering, analysis of typical cases of GIS engineering domestically and abroad, etc.
- The Course of GIS application refers to the main functions of GIS, techniques of data collection and quality control, data search and management technology, the application of spatial analysis model, Compilation of electronic map, Web-GIS spatial information publishing, the operation and usage of the main software of GIS, GIS application practice, etc.

In the arrangement of teaching planning, *Fundamentals of RS* may be put after the learning of physics, that is, in the first or second term of the second academic year *RS Image Processing* is suggested to be in the first term of the third academic year, while *Analysis and Application of RS Image* may be put in the second term of the third academic year.

As for the core curricular regarding GIS, it is suggested that *Principle and Methods of GIS* is put in the second term of the

second academic year; *Design and Development of GIS* in the first term of the third academic year; *GIS engineering* in the second term of the third academic year; *GIS application* in the first term of the fourth academic year so as to be combined with practice of undergraduates.

The hours of each course is related to the richness of courses contents, the quality of students and the requirement of students' capability. Then it is left to various universities to decide in terms of their GIS major situation.

Designing of core courses for GIS major scientifically and objectively involves many factors such as the goal of the development of undergraduates in GIS major, the social demand of knowledge structure and basic quality of undergraduates in GIS major, staff quality and the soft and hardware environment of laboratory. Therefore, the tentative program for the arrangement of core courses needs to be further proved and discussed.

## REFERENCE

- [1] Ministry of Education P.R.C, Notices about promulgating *Major Catalogues for Undergraduates in Average Universities and Colleges* (promulgated in 1998), July, 6,1998, <http://202.205.177.129/wreports/index.htm>.

## Appendix: Abbreviations in the Tables 1 - 3:

Appl. – Application  
RS –Remote Sensing  
Struc. – Structure  
DBMS –Database Management System  
DEM – Digital Elevation Model  
Experi. RS Ima. Pro. –Experiment of Remote Sensing Image Processing  
Geodesy and Carto.— Geodesy and Cartography  
Geog. – Geography  
Info. – Information  
Intro. – Introduction  
Geosci.—Geosciences  
Sci. – Science  
Intro. to Navi. and Commu. –Introduction to Navigation and Communication  
Sys. –System  
Math. —Mathematical  
Tech. – Technology  
OS – Operating System  
Princl. – Principle  
Pro. – Processing  
OS – Operating System  
VRML –Virtual Reality Machine Language