GIS Development and Its Impacts on Geo-Spatial Education in China

Jing Li, Yunhao Chen, Jun Chen, and Wen Dou

Geoinfomatics Center, College of Resources Science & Technology, Beijing Normal University, Beijing, P.R.China 100875

Abstract

As a powerful tool to manage and analyze spatial data, GIS is developed quite fast in China since 1980s. The development of GIS brought an important challenge to geo-spatial education, made a huge change to traditional education on spatial information technology, and promoted the development of modern GIS education. By solving the problem, China has established a set of GIS training systems. However, the situation is still far from perfect. Led by the development of technology, the GIS training system stepped over three stages and keep on progressing. This paper introduces the development and current situation of GIS education in China, including degree training and on-job training.

I. INTRODUCTION

In recent years, there has been a dramatically increasing need for timely, accurate, more meaningful and more sophisticated spatial referenced information in many organizations, professions and disciplines. This has been creating profound changes in the spatial referenced information marketplace, simulating intensive activities and application projects to respond and satisfy user's needs, and leading to the formation of a new spatial information industry (Chen, 1992). Actually, the surveying and mapping communities are changing their directions to the creation, production, and delivery of new spatial referenced digital products, systems and services (Wang, 1992). Further, the desires and demands for new and more timely digital products have stimulates intensive R&D activities towards developing fully integrated digital systems which unify the disparate spatial information processing functions, and this is also leading to the formation of a new spatial information science and the breaking down of many of the old boundaries between disparate disciplines. In fact, many disciplines are related to GIS now. Combination and cooperation of multi-disciplines and multi-professions promote development on Geo-spatial information theory, technology and industry effectively.

GIS appeared at the beginning of 1980s in China. Its development can be divided into two major stages: 1980s and 1990s. The first stage is the beginning and testing stage. A series of basal researches related to GIS had been done, and some experimental systems had been established (He, 1992). Some GIS systems for urban planning began to be used in the period. It promoted GIS technical development, inaugurated new phase for GIS application in China, and laid down a good foundation in China for the second stage, which is overall application and development stage. In the second stage, R&D of GIS focused on the combination of GIS and national economic construction, and it has been widely used to provide varied analysis data and programs for various professions in national economic construction. A series of vocational GIS and spatial databases have been established and used in professional work.

The fast development of GIS industry has a very strong impact on the spatial information education in China. A lot of GIS professionals are required, especially high level professionals. As GIS professionals must have the new knowledge of multi-disciplines, which couldn't be provided by the traditional education for spatial information, GIS education has to be developed and traditional education system for spatial information has to make some changes.

II. EDUCATIONAL CHALLENGE AND GIS EDUCATION IN CHINA

Before 1970s, the education on spatial information technology in China focused on surveying and mapping. Founded in early of 1950s, Wuhan Technical University of Surveying and Mapping (WTUSM) and Zhengzhou University of Surveying and Mapping are the two universities specialized on the education of surveying and mapping. There are also departments and programs related to surveying and mapping or Cartography in some other universities, and more departments and programs have some courses related to surveying and mapping. They were principal bases for traditional education and training of spatial information technology, and also principal bases for education and training of modern spatial information technology in China. In 1970s, as Landsat data began to be used widely, education on remote sensing began to be one of the most important works in these departments and programs. By the end of 1970s, some universities have set up Cartography and Remote Sensing program, and offered M. Sc. Degrees. Remote sensing education became gradually the main part on spatial information education. In 1980s, with grow-

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ing application of remote sensing and GIS in China, the remote sensing education experienced expansion and rapid development towards the direction of GIS education, and some GIS courses began to open. In 1988, a Geographical Information Engineering specialty was set up in the Department of Photogrammetry and Remote Sensing at WTUSM. It is the first specialty which is specially designed for GIS education and training in China.

Since 1990s, the GIS education has been conducted widely throughout China. Now many students are studying in universities for their B. S., M. S or Ph.D degrees related to GIS, or learning some GIS courses. More than 100 universities and colleges in China offer courses related to RS and GIS at various departments (include surveying and mapping, geography, geology, earth science, environment science, forest, hydraulic engineering, agriculture, urban planning, mathematics, computer science, electronic engineering, and so on). According to LI Deren, more than 140 universities and colleges in China have set up specialties of GIS leading to B.S. degree by 2003, which is unexpected, and at least more than 20 of them also offer M. S. or Ph.D degree. The latest statistic has shown that 16 more universities set up specialty of GIS in 2003. Almost all of these universities focus mainly on the department related to geography or surveying and mapping. In some departments (for example, mathematics, computer science, urban planning, environmental science, and so on), even if they don't have GIS specialties, there are still some graduate students in the department learning and researching on GIS direction every year.

Being application-driven, GIS received the same attention as RS in department of geography in Chinese universities. In terms of weight in different specialties, RS and GIS takes up 39 percent in geography, 15 percent in geology, 12 percent in surveying and mapping, 10 percent in agriculture, 6 percent in mathematics, Computer science and electronic engineering or some other specialities as much as 18 percent in the same cases (Li, 1994).

There is no GIS specialty in department of geography from 1980s to early of 1990s, and GIS education is performed by specialty of "Cartography and Remote Sensing" in China. Departments of geography in some universities set up "Cartography and GIS " specialties and began to offer degrees of GIS in middle of 1990s, which made GIS education for degree promote to a new stage. Table 1 is the courses related to GIS (include 3 GIS courses and 3 remote sensing courses) for undergraduate students in " Cartography and GIS " specialty, department of geography, Peking University, which could be taken as the representation of GIS related course for undergraduate students in department of geography in Chinese universities and colleges. Students can select some courses freely, but total time must not less than 240 class hours.

The representation of GIS education in department of surveying and mapping at WTUSM is shown in Table 2. Since WTUSM is set up specially for education in spatial information technology, GIS is useful for almost all departments. In 1994, there were four major departments concerned with GIS education: Department of Geodesy, Department of Photogrammetry and Remote Sensing, Department of Engineering Surveying, and Department of Cartography. There were more than 100 professors and associate professors in these four departments, and annual student numbers were 420 undergraduate students, 30 graduate students, and about 20 doctor candidates. In Department of Photogrammetry and Remote Sensing, the Geomatics Engineering program had annual enrollment of 30 undergraduate students, 10 graduate students, and 3 doctor candidates (LI, 1994). Table 2 shows the GIS related courses for undergraduate students:

In the past few years, the structure of WTUSM has changed and some schools have been set up. At least four of them are

Table 1. Courses related to GIS for undergraduate students in "Cartography and GIS "specialty, Peking University

	Courses	Contact Hours
First year	C and C++ Language	51
	Software Engineering	51
Second year	Principle of Remote Sensing	51
	Surveying and Mapping	51
	Principle of GIS	51
	Principle of Data Base	34
	Computer Graphics	68
Third year	Computational Geography	51
	Digital RS Image Processing	34
	Spatial Analysis and Computer-Aid Cartography	34
	Remote Sensing Application	34
	GIS Application	51
	Computation Method	51
Fourth year	GIS Design	34
	DTM	34

Table 2. GIS related courses for undergraduate students in WTUSM in 1994 (according to Li, 1994)

Courses	Contact Hours
Computer Language	70
Laws and Regulations in Surveying and Mapping	30
Topographic Mapping	40
Photogrammetry	80
Digital Image Processing	70
Remote Sensing	50
Data Structure	40
Principles of GIS	70
Natural Resource Investigation	50
Computer Graphics	50
Principle of GIS	120
Study of System Engineering	40
C Language	70
Information System Design	50
Cadastral and Land Management	50
Photographic Techniques	50
Topology and Notation	40
Pattern Recognition	50
Image Interpretation	40
Data Principle and Design	40
AI and ES	40
Office GIS	40
Map Recognition	50

concerned with GIS education, which is School of Information Engineering, School of Land Science, School of Geo-science and Surveying Engineering and School of Urban Construction and Planning. More students (including undergraduate and graduate students) have annual enrollment.

Development of GIS education in Peking University and WTUSM could illustrate the development of GIS education in China. In 1997, Academic Degrees Committee of the State Council added two new sub-disciplines to the catalog of disciplines and specialties, which are *Cartography and Geographical Information System* belonging to *Geography* and *Cartography and Geographical Information Engineering* belonging to *Geodesy and Geomatics*. Table 3 shows the disciplines concerned with GIS in the catalog of disciplines and specialties for Ph.D. and M.S. degrees.

Policy of Academic Degrees Committee of the State Council of People's Republic of China stimulated the development of GIS education in universities greatly, and especially aroused the enthusiasm of bringing up high level professionals. Table 4 lists the most important universities which could offer Ph. D. degrees on specialties concerned with GIS in China.

III. GIS ON-JOB TRAINING

Though many students get their academic degree related to GIS in universities and colleges, and become professionals on GIS area, it still can't meet the requirement of GIS development. On one hand, it's lack in the professionals on modern spatial information technology as GIS industry develops rapidly, while on the other hand, the professionals who have been working on traditional professions, such as surveying and mapping, face to the problem of aging and singleness of their knowledge structure, and it's difficult to fit change in professions about spatial information technology. On-job training is the best way to solve the problem. It can help them to change their knowledge structure and grapple new technology, and promote human resource development on GIS area.

An investigation made by the State Bureau of Surveying and

Table 3. Disciplines and specialties concerned with GIS

Degree	Discipline category	Discipline(code)	Sub-Descipline(code)
Graduate	Natural Science	Geography(0705)	Cartography and Geographical Information System(070503)
	Engineering	Geodesy and Geomatics(0816)	Photographic Survey and Remote Sensing(081602)
			Cartography and Geographic Information Engineering(081603)
			Geodesy and Survey Engineering(081601)
		Geological Resources and Geological Engineering(0818)	Geodetection and Information Technology(081802)
		Computer Science and Technology(0812)	Computer Software and Theory(081202)
			Computer Applied Technology(081203)
Undergraduate	Natural Science	Geographical Science(0707)	Geographical Information System(070703)
	Engineering	Science of Surveying and Mapping(0809)	Surveying and Mapping Engineering(080901)
		Electrical and Information Science and Technology(0806)	Computer Science and Technology(080605)
	Management Science	Management Science and Engineering(1101)	Information Management and Information systems(110102)

Table 4. Specialties concerned with GIS leading to Ph.D. degree in some important academic unit of China

University	Specialties concerned with GIS leading to Ph.D. degree		
	Cartography and Geographical Information System	Cartography and Geographic Information Engineering	Photographic Survey and Remote Sensing
Wuhan University▲	√	√	√
Central South University▲		√	▲
Peking University△	√		√
Tongji University▲		√	▲
China University of Mining & Technology▲		▲	√
Shandong University of Science and Technology▲		√	▲
China University Of Geosciences		√	
Zhejiang University	√		
Ocean University of Qingdao	√		
University of Information and Engineering PLA▲	√	√	√
East China Normal University△	△		
Nanjing University△	△		
Nanjing Normal University△	√		
Zhongshan University△	△		
Lanzhou University△	△		
Beijing Normal University△	√		
Northeast Normal University △	△		
Shanxi Normal University△	△		

Note: ▲ means the unit is a first-grade discipline unit of Geodesy and Geomatics and △ means that of Geography

Mapping (1998) shows that now 51.3% professionals in GIS area are only 1-2 year experience, 55.1% are below 30 years old. It means that more than half of them are young people who just left university or college and began to work in a short time. They are the main force now and will be main force in future on GIS. However, they still lack experience and multi-disciplines knowledge, and need to know more by on-job training. The investigation also shows that for all professionals in GIS area, 71.8% hope to attend some training courses, so as for them to renew and expand their knowledge and keep touch with the latest development of GIS. It shows that on-job training is also one of the most important parts for GIS education.

The on-job training on modern spatial information technology began in 1970s in China. From 1975 to middle of 1980s, National Remote Sensing Center of China organized a series of training courses for remote sensing, which promote effectively the development of modern spatial information technology in China. Several thousands participants attended these courses. In the past 20 years, they are the main force on spatial information technology in China. With the development of GIS application, the focal point of training changed gradually from remote sensing to GIS from the last few years of 1980s. Many universities, colleges, institutes and companies participated in it. Every year many participants fulfill their training and come back to their working position, and become an important force for development of GIS industry. However, GIS on-job training is not systemic and organizational like remote sensing on-job training. It still needs be modified so as to meet challenge coming from GIS development.

In recent years, some agencies began to pay much attention on GIS education and try to solve this problem. Some of them already made plan to implement GIS on-job training. For example, GIS Association of China (CAGIS) set up a GIS education professional committee to coordinate work and exchange experience about GIS education among various organizations, professions and disciplines. CAGIS also organized several training courses and workshop about GIS to make more professionals know GIS technology and application. Now it is planning to do an investigation on later situation of GIS education in China, and will make further plan to promote human resource development in GIS area based on the investigation. State Bureau of Surveying and Mapping also made a detailed plan for their employee to implement GIS training. It will give different training courses and content for participants with different levels and different requirement. Based on the plan, participants are divided into three levels: primary level, middle level and advanced level (State Bureau of Surveying and Mapping, 1998).

The main training of participants in advanced level is system designing and planning of GIS, and it's expected that they could know the latest development of GIS, and have the capability of planning and system analysis. The core courses of GIS training for them are shown as following (State Bureau of Surveying and Mapping, 1998):

- Design and analysis of GIS
- Information Economy

- Digital spatial data communication network
- Spatial analysis method in GIS
- Project Management
- GIS evaluation and planning
- Spatial decision-make support system
- Advanced GIS

Participants in middle level are mainly system researchers and developers, and should know the GIS principle and core technology. The core courses of GIS training for them are shown as following:

- Design of spatial data base
- Processing and analysis of remote sensing image
- Digital Mapping
- Data structure and data model of GIS
- Digital map model and application
- Spatial data quality in GIS
- GIS engineering application and development
- Design of electric map and theme map

Participants in primary level work mainly for system operation and data collection. They need to know the principal knowledge about RS, GIS, GPS, computer and databases. They also should have the capability for system operation. The core courses of GIS training for them are shown as following:

- GIS principle and application
- Digital photogrammetry
- Principle of remote sensing
- Data base principle and application
- Application for GIS basic software
- Application of computer and instrument
- Digitalize map

Based on their different requirement, there are four training types for every level: dissemination type, supplement type, innovation type, and discussing type. Different courses design for different training types. It is obvious that implementing of the plan will promote greatly GIS on-job training.

IV. SUMMARY

With the rapid growing of GIS technology and industry, GIS education also develop fast in China. A set of GIS training systems have been established, especially on degree training. Many universities, institutes and colleges have established related departments or been taking related curriculums. And Academic Degrees Committee of the State Council added two new sub-disciplines related to GIS to the catalog of disciplines and specialties, which stimulated the development of GIS education greatly. Some agencies also tried to make on-job training more accessible, flexible and effective. However, it still can't meet all requirements coming from GIS industry, and on-job training still has much to be improved. More effort and modification should be done on both degree training and on-job training. It is obvious that the development of GIS will continue to bring more challenge and impetus to GIS education, which will add difficulties to the issue. We have no choice but to try our best to implement the GIS education system, which would lead to a benign circle of GIS education and GIS industry.

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REFERENCES

[1] Chen, Jun, J. Maclaugin, 1992, Strategic direction of surveying and mapping: a perspective, *1992 ACSM/ASPRS Congress*, Vol.1, pp. 254-261.

[2] He, Jianbang, Jingtong Jiang, 1992, A review of the development of GIS in China (1986-1990), *Proceedings of the International Colloquium on Photogrammetry, Remote Senisng and GISs*, pp.294-302, Wuhan, May 11-14,1992.

[3] Li, Deren, Xiaoqin Hu, 1994, GIS Education in China, *Proceedings of ISPRS Commission VI Symposium on Facing the Chance and Challenge*, pp.3-8, Beijing, Oct.10-13,1994.

[4] State Bureau of Surveying and Mapping, On-job Training Center of State Bureau of Surveying and Mapping, 1998, Guide for GIS On-job Training Course (in Chinese).

[5] Wang, Zhizhuo, 1992, Recent evolution in surveying and mapping discipline, p.270-275, *Proceedings of the International Colloquium on Photogrammetry, Remote Senisng and GISs*, Wuhan, May 11-14,1992.