GEO-SPATIAL INFORMATION TECHNOLOGY EDUCATION IN CHINA, PRESENT AND FUTURE

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KEY WORDS: GIS, Higher Education, Review, Achievement, Present, Prospect

ABSTRACT:

With the industrialization of GIS and the enhancement of GIS accreditation by government, enterprise, and society at the beginning of the 21st Century, geo-spatial information technology has experienced rapid development and broader diffusion in China. Meanwhile, GIS education in China also grows into a new level in manifesting itself on large-scale, hierarchical and comprehensive cultivation. The education resources are relative abundant; the teaching modes and methods are also becoming multiform. With opportunities and challenges that coexist under the new circumstances, the rapid growth of GIS education brings us urgent problems as well as wonderful hopes. The problems include unbalanced development of education, low integration amplitude of courses and under-developed education systems. How to solve these problems has become the focus of the public attention. In this paper, the main achievements and problems of GIS education in China are reviewed. Suggestions are then made for the development of GIS education in the near future in response to the growing GIS market and for better integration with international GIS education on the aspect of education level, teaching mode, teaching practice and cultivation system.

1. BACKGROUNDS

GIS education in China is active and flourishes at present. However, as an emerging technology and subject, the development of GIS experiences a relatively short period of time, especially the education of GIS. So, there are some problems needing to be solved urgently of GIS education. Both the domestic and overseas GIS education systems are under-developed and the standardized teaching modes are under-formed as well. Therefore the existing specialized cultivation goals, curricula system settings and teaching methods restricted the improvement of cultivation quality to a certain extent. With great opportunities and challenges, some issues should be put on the agenda, which include GIS subject orientation, cultivated goals and modes, major settings, curricula system construction and the adapted teaching content and method.

2. THE DEVELOPMENT PROCESS

GIS researches began in the late 1960's, while the study in China mainland started a few years later due to a variety of reasons.

Fig.1 clearly reflects the various milestones in the development of GIS and its education in China. In 1977, Professor Chen Shupeng decided to engage in the research of GIS and RS system. In 1978, Professor Wang Zhizhuo proposed an academic thought of full digitized mapping. Professor Chen Shupeng built the first laboratory of GIS in the Institute of Remote Sensing Applications Chinese Academy of Sciences (IRSA) in 1980 (Fig.1-1), and it has been considered the sign of the beginning of GIS research in China. Since then, the early research on GIS started in China. In 1986, the State Key Laboratory of Resources and Environment Information System was established in the Institute of Geographic Sciences and Natural Resource Research (IGRE). In 1988, the State Key Laboratory of Mapping and Remote Sensing Information Engineering was built in Wuhan Technical University of Surveying and Mapping (WTUSM) (Fig.1-2).

The higher education of GIS in China emerged at the end of 1980's and developed rapidly. The students majoring in GIS were enrolled in Wuhan in 1988 for the first time (Fig.1-3); the first GIS book named 'The Introduction of Geographic Information System '(by Prof. Huang Xingyuan) was published by Higher Education Press in 1989(Fig.1-4); the first master education specialty was established in Wuhan in 1993(Fig.1-5). In 1994, 'GIS Association' of China and 'Popular Science Education and Professional Committee' were set up (Fig.1-6). In 1997, 'Cartography and Geographic Information System' and 'Cartography and Geographic Information Engineering' were set as the second class discipline under the two first class disciplines which were Geography and Surveying. And the graduate students and Ph.D candidates majoring in the specialties registered in the year (Fig.1-7). In 1998, the specialty number of high education was adjusted from 504 to 209 by the Education Ministry of China. However, Geographic Information System was still added as a science bachelor major based on Geography (Fig.1-8). At the turn of the century, the precious opportunity of GIS development was held and a perfect education system was formed for cultivating the GIS undergraduates, postgraduates, doctor, postdoctoral and overseas students. From then on, GIS education in China ushered in a period of great development. In 2000, about 37 universities and colleges have set up the GIS education specialty (Fig.1-9) and the number doubled in 2002 (Fig.1-10).

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In 2004, GIS specialty in China has covered over 120 universities and colleges; and thousands of undergraduates and postgraduates graduated each year (Fig.1-11). At present, China mainland have the most institutions of GIS educations in the world and more than 150 universities and colleges have GIS bachelor education program according to the 2006 statistics (Fig.1-12).

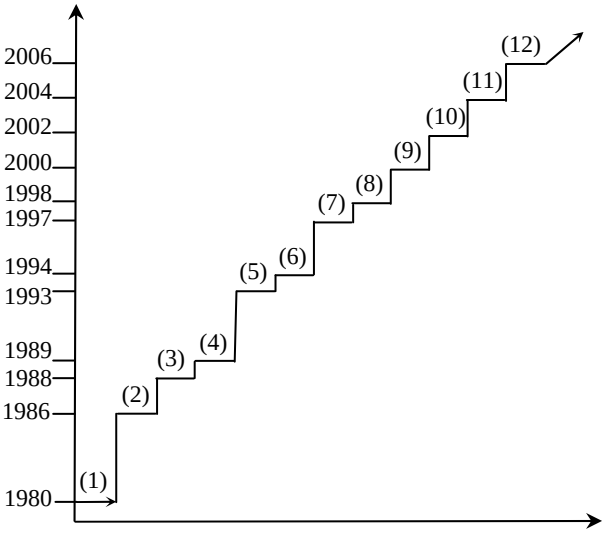

Figure.1. The milestones of GIS development in China

3. ACHIVEMENTS

3.1 Professional GIS education is large-scale, hierarchical and comprehensive

GIS bachelor education program covers almost all provinces in China (fig.2, fig3). Master and doctoral students are enrolled not only in universities but also in state-level research institutes. The level of graduates ranges from bachelor to post-doctor and overseas students. The complete education system is consisted of various technical training in colleges and corporations, popular education in secondary schools, and continuing education for adults.

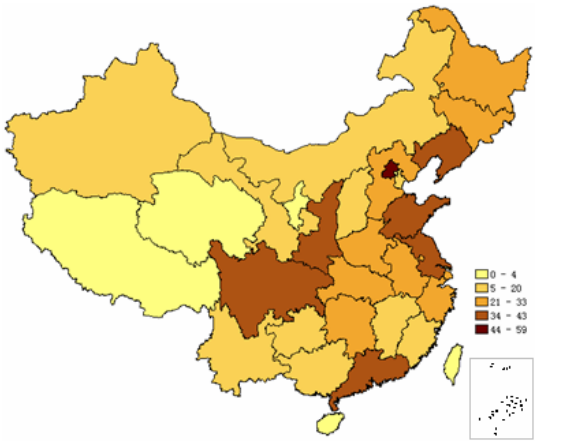

Figure.2 Distribution map of the number of colleges in each province of China

The comprehensive education in GIS covers the disciplines of geography, surveying and mapping, and computer science, with students trained with different specialties such as science, engineering, intersection of science and engineering and other correlative fields as well. The types of GIS education in China are as follows.

(1) The education system cultivating bachelor and master is based on the background of Geography, which highlights the advantages of GIS applications, including integration of professional (urban planning, land use, etc.) geographical model and establish the decision-making GIS for supporting sustainable development. Such university as Peking University, Nanjing University, Nanjing Normal University and Beijing Normal University are of this kind.

(2) The cultivation system is based on the background of Surveying and Mapping, which highlights advantages of information acquisition and data processing, including maps and remote sensing technologies, 3S integration and the establishment of multi-scale and spatial-temporal GIS. Wuhan University, China University of Geosciences and China University of Mining are such kind of universities.

(3)The cultivation system based on the background of Computer Science, like Tsinghua University, which outstands itself on GIS software design, system development and integration. And it also pays attention to solving the openness of the system, integration, interoperability, data modelling and database management, and other key technologies.

(4)The cultivation system in which the IRSA and the IGRE apply has the features of research-driven and research-based.

3.2 Education resources are abundant and optimized

The GIS education resources in China have experienced from shortage to relative abundance, reflecting in the following aspects.

(1) On one hand, teacher resources become richer when large quantities of high quality postgraduates join teaching teams; on the other hand, the professionals in universities and research institutes devote themselves into the development of GIS education while they actively participate in cartography, geographic information systems, remote sensing, and other

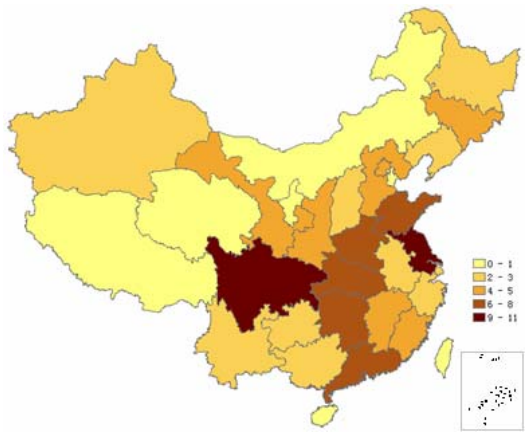

Figure.3 Distribution map of the number of colleges having undergraduate specialty of GIS

fields of scientific research and technological development. A stable, high level scientific research and technical development team has been already formed. Then it effectively promotes the

construction of teacher team. Meanwhile, the structure of GIS teacher team is currently undergoing great changes and the a teacher team with highly education, high quality and optimized knowledge structure is forming. They all have laid the favourable foundation for the development of GIS education.

⑵ The establishment and development of a number of well equipped state and province key laboratories have provided excellent hardware environment for GIS education. Except for the State Key Laboratory of Resource and Environment Information System in IGRE and the State Key Laboratory of Mapping and Remote Sensing Information Engineering in Wuhan University mentioned above, several key laboratories were established in succession which include the State Key Laboratory of Remote Sensing Science in Beijing Normal University, the Education Ministry Key Laboratory of Three-dimensional information acquisition and application and the Beijing Key Laboratory of Resource Environment and GIS in Capital Normal University, the Education Ministry Key Laboratory of Virtual Geographic Environment in Nanjing Normal University, the Education Ministry Key Laboratory of Geo-Information Science in East China Normal University.
These key laboratories not only have a large number of excellent software and hardware facilities, but also have rich experience in construction projects for GIS. They all have provided valuable resources to the GIS education.

⑶ With the publishing of several sets of high-level GIS teaching materials, the voids of teaching materials have been effectively filled. Since the first GIS teaching book written by Professor Huang Xingyuan in 1989 was published, over 200 GIS specialty teaching materials have come out. And there also have been a number of representative series materials. The 21st Century Colleges and Universities GIS series materials organized by Nanjing Normal University and published by the Science Press, had well connection with the latest international GIS materials by their structures and content systems. The series materials are close-oriented to the demand of teaching, especially in the courses such as GIS Software Engineering, Spatial Database, GIS Integration, Geographic Information Sharing, GIS Algorithm, Geographic Modelling, Digital Elevation Model, Digital Map, Virtual Urban Construction, and Web GIS. According to the applications of various fields, GPS, Environmental Remote Sensing, Remote Sensing Digital Image Processing, and other related curricula teaching materials were published as well. The series teaching materials greatly promoted the development of GIS education. In addition, the series materials which were named 'Cartography and GIS' and organized by Wuhan University, focused on Computer Cartography, GIS Spatial Analysis and GIS Project Management. The 21st Century Colleges and Universities teaching materials of the Science Press, brought forward the teaching materials which included Spatial Data Error Processing, GIS Spatial Analysis and Web GIS. From the perspective of the current distribution of GIS teaching materials in China, the three series materials above mentioned can cover almost all of the GIS basic professional courses and specialized ones. They are widely used in the GIS teaching in relevant universities due to their commonalities.

⑷ The establishment and demonstration of the State and province key disciplines of GIS have played an important role in GIS education. A few universities have established the state key disciplines, like Nanjing Normal University, Wuhan University, Peking University, Nanjing University and Nanjing University of Information Engineering. Meanwhile, many universities have owned the provincial and municipal key disciplines of GIS. The GIS education systems in these universities are quite perfect. Moreover, exquisite GIS courses of state, province, and school are also established actively. Five or six state and dozens of province GIS network exquisite courses provide abundant resources and much convenience to the GIS learners. Furthermore, some well-known domestic and foreign software companies organize systematic trainings for the social and competitions for colleges and universities regularly. It provides a good atmosphere for the GIS education undoubtedly in China.

3.3 Teaching methods and modes become multiform

With the improvement of teaching resources and conditions, various methods and modes are applied in GIS teaching. The diverse enlightened and bilingual teachings are adopted to keep the balance between basic theory and practice. In the process of teaching, self-study, reading reference, writing course papers and class discussion are all encouraged. Advanced teaching methods using multimedia and word-wide web prevail too. Multimedia teaching (three-dimensional materials) is helpful in improving students' enthusiasm and learning efficiency. Students can acquire he latest development trends in international and domestic and teaching contents are enriched by network teaching.

4. ISSUES AND PROBLEMS

4.1 The development of GIS education is unbalanced

Due to the affection and constraint of many factors such as basic conditions, school backgrounds, economic levels, teaching quality and laboratory equipments, there are much difference of GIS specialty construction and development in China.

Firstly, the development of GIS education among various regions is unbalanced. There objectively exist significant gaps among the regions and the schools, which include teaching resources, education levels and qualities of specialty education. In general, the education resources of key or comprehensive universities are abundant whilst local universities often face the shortage of resources. Colleges and institutes that admit masters and doctors mainly locate in few more-developed provinces(Fig.4, Fig.5). Doctoral students intensively distribute in the eastern and central part of China. Fig.4 shows that GIS education develops better in the area of Gansu, Shaanxi, Hubei, Beijing, Jiangsu and Jilin. Among them, Beijing shows its great advantages; Jiangsu, Jilin, Gansu are followed; and Shandong, Hubei, Shaanxi, Guangdong and Zhejiang have doctoral distributions as well. Fig.5 reflects the difference of the education levels of GIS doctors in regions and their strong relationships with economic conditions or natural environments of the regions. Local colleges' conditions are not so good which present with the lack of software, fundamental data, or teachers with much teaching and research experiences. It's hard to build an integrity teaching system in local colleges, for little GIS professionals are willing to teach there.

Secondly, the levels of GIS professionals are unbalanced. Because of the large variation in resources and conditions, the abilities of graduates are inevitably different. Commonly, the focus of GIS teaching at local universities is on applications.

The GIS education systems in some colleges are not systematic and the teaching contents are too broad, abstract, and superficial. With GIS theories and processes not being taught, teachers only show the operation of GIS software. And secondary development of GIS is not emphasized. As a result, education levels of GIS are unbalanced and GIS basic educations are void.

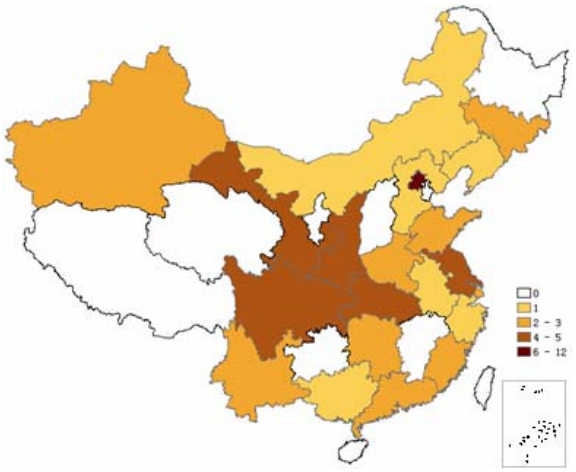

Figure.4 Distribution map of the number of departments which accept master students of GIS

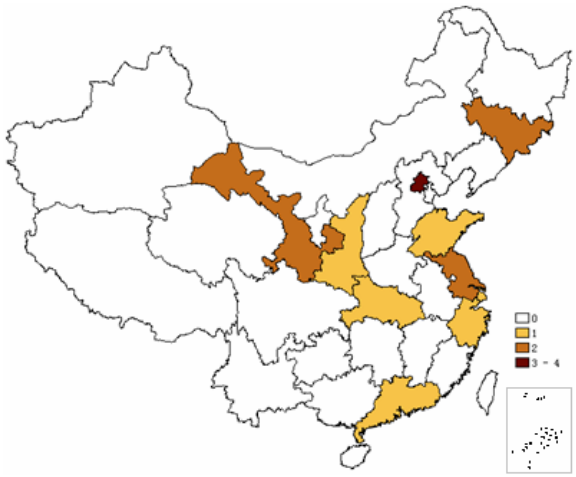

Figure.5 Distribution map of the number of departments which accept doctor student of GIS

4.2 The GIS courses are not well integrated with other curricula

As a new and cross discipline based on many other ones (e.g. computer science, geography and surveying and mapping), the mode of GIS curricula is complex and lack of continuity, integrity and complementary. In order to cover most courses in relation to the specialty, the number of the courses taught in many colleges and universities is as many as 60. Therefore, the teaching of each course is abstract and superficial, even deficient of pertinence and emphasis. Without consideration of their own characteristics, many local colleges copy the GIS education system from key universities and this result in many nominal courses.

At present, there are four modes of GIS curricula system, including geographic category, mapping and remote sensing category, computer science and technology, and GIS specialty. They form the core and primary courses of a GIS bachelor specialty. The determination of the core curricula consist of the standards defining the aim of the curricula. They are as follows.

The curricula should not only allow students master basic knowledge of GIS, but also understand the forefront of the field; The curricula should benefit the students to the systematic study of knowledge and lay the foundation courses structure of the knowledge and ability for students' further study; moreover, it should emphasizes on the new technology, new integration methods of GIS.

With rapid development of GIS, the knowledge system should also be updated timely. So, the curricula should keep advanced with new development of theory, method and technology of GIS by professional progress and new technology lectures.

The specialty in China relies on the related fields such as agriculture, forestry, geology and hydrology and so on. In order to make students be competent of applying GIS to the fields, how to integrate with primary courses and related professional ones is an important issue. However, there still exists conspicuous difference in the GIS curricula settings among the colleges and universities for some reasons such as relied disciplines, specialty orientation, teaching qualities and facility conditions.

4.3 The GIS education system is still under-developed

A mature system and mechanism of GIS education has formed in developed countries of Europe and America in the aspects of theory, technology, research, education, science popularization, institution organization and related policies of GIS. There are various GIS education forms in the countries including education and training from famous software corporation, professional education website, free sharing data, and well-developed communication mechanism of GIS education.

The standards of the specialized geo-spatial information technology education have not been established. The institutes that are capable of supervising, organizing and managing GIS education programs are still much less than the demand. At present, the organizations responsible for coordinating and guiding the discipline construction of GIS include Geography Teaching Direction Committee (Education Ministry), High-School Survey Discipline Teaching Direction Committee, and GIS Association (Education and Science Popularization Professional Committee). However, Geography Teaching Direction Committee mainly focuses on the discipline construction of geography science, resources, environment and city-town plan management. While Survey Discipline Teaching Direction Committee concerns more about survey engineering discipline. As a result, both the committees refer to the guidance of GIS discipline development but the guidance is deficient obviously. Meanwhile, Chinese GIS Association can hardly regularize and evaluate the national GIS education. In contrast to overseas education of GIS, it is simple in China representing lack of training modes according to different social requirements, lack of cross-discipline education and minor Courses, lack of practical talents coming from inter-disciplines，low popularization of GIS certification, poor GIS service in university campus. In addition, there are few platforms that teachers can regularly communicate and exchange experience in teaching and research. Data sharing and professional websites on GIS education are absent. And

international cooperative communication takes the place of the mode of united cultivation GIS students prevailing in overseas to satisfy society requirement.

5. THE FUTURE

5.1 Establishing GIS education programs at different levels according to the needs

Different teaching contents should be offered and different methods be adopted for different level learners. Learners shall be distinguished as general operators, application developers, project designers and advanced researchers. Correspondingly, different education levels shall be adopted as public, application, degree, and research courses. Meanwhile, the current uniform education mode for cultivating GIS talents should be converted to multiform modes that will meet demands at different levels. On the panel discussion of "21-centry Higher School development stratagem", the GIS education was classified into the masses level (compulsory course), the application level for vocational education and junior education, professional level for undergraduate students and elite level for postgraduate and doctor students, which accord with GIS education situations of China.

The key problem is that relevant departments should make the corresponding policies and take measures to advance the development of GIS education in China. To internationalize the GIS education program, more joint-teaching programs of GIS with international institutes are expected in the future.

5.2 Hands-on practices should be intensified

As a discipline paying attention to practice, GIS technical characteristic is more important comparing to its theory one. Enhancing the innovative and comprehensive ability of students will be emphasized in the first place. The low proportion of practical courses and application training in whole GIS education is very common in higher schools at present, especially in local higher schools. The practice time and site are limited because of lack of fund. It is advisable to assist basic theory courses with simultaneous exercises. It would be better to set up an experiment in each special topic and practical steps would be through out the whole process of GIS course teaching. Except for the exercises in laboratory, periodical experiments should arrange to make sure students capable of both operation as well as theory. Guided and independent experiments should be focused on the combination including validation experiments, integration experiments and innovation experiments, concentrated teaching experiments and free experiments, laboratory experiments and experiment in production departments.

5.3 Comprehensive, multiform and interactive teaching packages should be developed

In order to improve teaching quality, comprehensive, multiform and interactive teaching packages should be developed. The packages should combine new education ideas, techniques, methods, problems to be solved. And they should integrate theory, practice, and examination. It should be integrated of various education resources like teaching facilities, teaching resources, practice sites and so on. The education programs based on internet and multimedia should also be further developed and promoted.

With the principle of that the course are learned easily and taught efficiently, they should be applied of various teaching modes such as courseware demonstration, self-learning, discussion and practice using computers. The multimedia courseware will mainly be used in demonstration of key problems, difficult problems, images materials and simulations in the course. With much information, the courseware should be well organized. By self-learning and discussion which include using internet course, reading material and doing exercises, students can learn non-key problems and descriptive contents. The learning effects can be checked according to discussion, question and homework. Modern education technology like internet and computer-assisted teachings should be used widely in computer practice by distributing teaching resources which reflects the interaction of teaching and learning. In order to develop their own characteristics, students are encouraged to learn independently. Tutorship and reference books are offered to students who interested in some courses. Meanwhile teachers help the students to increase learning quality and efficiency.

To promote students' comprehensive abilities, a integrative examination system including quiz in classroom, online-test and final exams should established. Examination plays a key role in perfecting the teaching. There's only one examination called final-exam for traditional teaching mode. The deficit is that students can not learn the knowledge that they're not well mastered although they know the mark after the exams. By the combination of tests with final-exams, theory tests with practice exams, quizzes in classroom with online-tests, the periodic examining and teaching mode is formed. In order to understand students' learning condition, promote their learning interest and help them to master more knowledge, a variety of examination forms like discussion, speech, thesis, homework and experiments are used.

5.4 An appropriate quality assurance mechanism needs to be established

Without a professional institution which supervises and guides GIS education effectively in China, a authoritative organization should be established at once to perfect the specialty settings and evaluate teaching quality by formulating its standards, to keep the integration of different courses by setting up the courses as a whole, to ensure the systematic and integrity of the teaching material by compiling overall, so that teaching resources can be shared effectively.

With their important guidance, the groups which direct education and consist of experienced experts should be established to supervise teaching quality of GIS professional courses, set reasonable teaching programs, advance operation ability of students and promote teaching level of teachers by making balance in both academic and practice teaching. The teaching levels of teachers can be improved by attending in advanced studies.

At present, there are several urgent tasks which should be done:
(1) draw up the GIS specialty standards,
(2) evaluate the teaching quality of GIS courses,
(3) formulate the setting plan of GIS core courses,
(4) establish teaching material compiling committee for GIS specialty,
(5) train teachers who teaches GIS professional courses,
(6) set up demonstration and practice sites of GIS specialty.

Being compiled by some university, the current teaching materials usually focus on its own teaching requirement particularly in the aspects of their structure, content organization and knowledge points setting. So, they are hard to take the other universities' education need into consideration. Meanwhile, the similar teaching materials complied by different universities will make complementation in content organization for each other. If the material compiling work can be done by cooperation of several universities, the above problems can be overcome in a certain extent.

With the overseas successful experiences of GIS education being make reference, GIS education systems of different levels based on different talents requirements should be construct and improve which includes senior professional education, science popularization and certification training according to the GIS education situations in China. Moreover, there is a strong relationship between GIS education and the education guideline, policy, law and regulation. So, the relative policy should be put up to develop the GIS education in higher school. The functional departments should establish laws and statutes including basic data construction, data normalization, basic data sharing, data service with compensated and system safety as soon as possible. Because of the insufficient understand of GIS for the public, essential measures should be take by the media, education system and government institution to popularize the knowledge of GIS and promote the development of GIS. In a word, to improve GIS education in China and achieve advanced level in the world need the endeavour of the public.

Besides, the international education and union-cultivate modes of GIS education should be popularize. In order to be geared to international cooperative researches, foreign experts would be engaged to guide student on his thesis and research.

6. SUGGESTIONS

Great achievements of GIS education and personnel cultivation in China have been gotten. GIS specialty covers and is driven forward by both science and engineering courses based on their original subject advantage. They promote the development of GIS education and the situation will remain in a quite long time. Much attentions, researches and rational thoughts should be excited because of the explosive development of GIS education in China. There are many urgent problems of GIS education in China including obvious differences of teaching resources, slow construction pace of the discipline, obscure training objects, bad teaching environment and lack of teaching resources. Being the keys of cultivating GIS talents, the problems should be solved at once to improve the quality of GIS education.

With GIS discipline normalization, the supervision of GIS specialty setting, the design of teaching plan and the normalization of teaching content should be enhanced by national education director department to develop the new discipline orderly. The problems existed in current GIS education are discussed in this paper to promote GIS education in China. By teaching quality of GIS specialty improved, GIS education in China will be not only great on scale but also superior in the quality of GIS talents.

REFERENCES

Bian, F.L., 2007. Problem, Innovation and Development of GIS Higher Education in Our Country. Geomatics World, 4(2),4-8.

Chen, J., Li, J., He, J.B., et al, 2002. Development of Geographic Information Systems (GIS) in China: An Overview. Photogrammetry and Remote Sensing, 68(4),325-332.

Du, P.J., Li, J., Zhang, H.R., et al, 2007. Discussion on Specialty Education of GIS based on UCGIS Geographic Information Science and Technology Body of Knowledge. Geomatics World, 8(4),54-62.

Du, P.J., Yan, Z.G., 2005. A Study of Establishment of Computer Course in GIS Speciality. Bulletin of Surveying and Mapping, (1),63-66.

GIS Association, 2004. Development, Characteristics and probe of GIS Education in China. Geomatics World, 2(5),16-19.

Huang, X.Y., Ma, J.S., 2002. A Discussion on the talents education of college GIS specialization. **Remote Sensing for land & resources,** 53(3),5-8.

Li, D.R., 2003. **About the construction of GIS discipline from** the development of surveying and mapping. Science of Surveying and Mapping, 28(4),4-6.

Li, J.X., 2006. The state analysis of Mapping and Geography Information Engineering Speciality. **Remote Sensing for land & resources,** 1,87-88.

Li, Z.L., 2003. GIS Curricula at overseas universities. Geomatics World, 1(4),35-40.

Liu, M.L., Huang, P.B., 2002. A Comparative Research on GIS Curriculum System and Structure at Home and Abroad. Scientia Geographica Sinica, 22(6),747-752.

Long, Y., Tang, G.A., Lv,G.N., 2006. Constructing the Nation-grade Excellent Course of GIS Based on Multidimensional Teaching Pattern. Bulletin of Surveying and Mapping,12:69-72.

Morton, E., 2000. GIS and educational and instructional challenges. Geographical Systems, 2:23-29.

Sheng, Y.H., Guo, Z.D., Du, P.J., et al, 2000. Curricula of GIS: Teaching and Some Discussions. Bulletin of Surveying and Mapping, (6),40-42.

Tang, G.A., Zhou. W., 2005a. Exploration and Practice for construction of advanced GIS course. Geo-information Science, 7(2),65-69.

Zhao, X.A., Yang, J., 2000. Sustainable Development and RS, GIS Education in China. Bulletin of Surveying and Mapping, (6),38-39.