# GEOMATICS VOCATIONAL EDUCATION IN CHINA: CURRENT SITUATION AND RECENT DEVELOPMENTS

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**KEY WORDS:** Geomatics, Vocational Education, Discipline, Curriculum Standards, Teaching Resources, Training Platform.

**ABSTRACT:**

Geomatics vocational education (VE) is very important for the high-quality development of geomatics industry and high-level supply of skilled talents. Firstly, the paper briefly introduced the development history of geomatics VE in China, and summarized the current status of geomatics VE. Secondly, the paper analysed the issues and problems of geomatics VE, including insufficient input, ambiguous orientation, slowly technology updating, weak teaching staff and closed communication environment. Next, the paper reported the recent reforms of geomatics VE, including the revision of discipline catalog, training objectives and requirements and recommended curriculum standards at different levels. Then, latest developments of teaching resources and training platform are discussed. Finally, the paper proposed an outlook of geomatics VE in China.

## 1. BACKGROUND

Geomatics vocational education (VE) is an essential part of geomatics education, which is the key way to cultivate diverse geomatics skilled talents, inherit geomatics skills and promote employment and entrepreneurship. Geomatics industry is a high-tech industry with technology-intensive characteristics, and the geomatics skilled talents are the backbone of the industry (Jia, 2013). Since the 21st century, the geomatics industry has made great progress in China (Li et al., 2014). Geomatics VE has been booming by strong growth of geomatics industry, and the scale of secondary and higher geomatics VE has been continuously expanded. The knowledge structure and comprehensive ability of geomatics talents should have a higher level to adapt to the needs of development and technological innovation of geomatics industry. However, compared with general education, the emphasis and input on VE are still insufficient. The existing training objectives, discipline setting, curriculum construction and training mode are not suitable for the development of new technology and restrict the improvement of training quality to a certain extent, which leads to the shortage of qualified skilled talents and the prominent contradiction between supply and demand (Tang et al., 2008).

Thus, this paper summarized the history, current status and problems of geomatics VE in China, discussed the recent developments and practices on discipline catalogue, requirements, curriculum standards, teaching resources and training platforms, and then proposed an outlook of geomatics VE in China.

In this paper, the historical data comes from "The History of Chinese Surveying and Mapping Education" and "Secondary Professional and Higher Vocational College Education in New China (1949-2000)". The statistics comes from the Ministry of Education and Proficiency Skill Appraisal and Guidance Center of Ministry of Natural Resources. Other analysis materials come from the investigation and research materials carried out in cooperation with the revision of the discipline catalog and professional standards of geomatics VE since 2019.

## 2. HISTORY AND STATUS

### 2.1 History

The history of geomatics VE can be traced back to the end of 19th century in China(Wang et al., 2011). In 1897, the Beiyang School of Geomatics was founded in Tianjin by the Military training department of the Qing Dynasty. Subsequently, Baoding Geomatics School (1902), Peking Army Geomatics School (1904) and Liangjiang Army Geomatics School (1905) were founded. In 1906, geomatics schools were established in all the provinces according to the order of the Qing Dynasty, including the majors of triangulation, topography and cartography. However, just a little number of students were enrolled and served in military surveying. Meanwhile, Shanhai Guan Railway School, Shanghai Nanyang School offered geomatics curriculums.

In the republican period, the first vocational school with geomatics major was established in Nanjing, named Hohai Engineering Special School. In 1931, the former Peking Army Geomatics School was restored in Nanjing and renamed Central Army Survey School. The majors of triangulation, topography, aerial photogrammetry, cartography and surveying instruments were established, including the levels of tutorial class, technical school, undergraduate and college. According to incomplete statistics, more than 2240 geomatics skilled talents were cultivated from 1918-1945 in Central Army Survey School. In 1946, the Geomatics School of Northeast Democratic Allied Army was established in Changchun and later renamed Northeast Military Geomatics School, which was the predecessor of Topography Academy of Chinese People's

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Liberation Army. The schools above-mentioned had cultivated a large number of geomatics skilled talents, whom made important contributions to geomatics VE in the new China.

To meet the needs of national defence and economy construction, geomatics VE in the new China had experienced the development process of initial construction, growth and expansion. From 1949-2000, 54509 secondary vocational level (Table 1) and 17704 higher vocational level (Table 2) geomatics skilled talents were cultivated by geomatics secondary vocational colleges, higher vocational colleges and ordinary universities (Shen and Xu, 2012). The majors included topography, geodetics, aerial photogrammetry, cartography, engineering surveying, mine surveying, cadastration, geographic information system, etc. A distinctive geomatics VE system was formed during this period, including teaching staff, discipline, teaching plan, teaching material, teaching mode, practice, etc.

| Period | Secondary vocational colleges | Other colleges | Total |
|---|---|---|---|
| 1950-1952 | 60 | 1109 | 1169 |
| 1953-1957 | 5143 | 2122 | 7265 |
| 1958-1970 | 9826 | 3204 | 13030 |
| 1971-1976 | 2652 | 1059 | 3711 |
| 1977-1985 | 7940 | 3757 | 11697 |
| 1986-1995 | 10770 | 1297 | 12067 |
| 1996-2000 | 4804 | 766 | 5570 |

**Table 1**. The secondary vocational level geomatics skilled talents cultivated by 1950-2000

| Period | Graduation | Correspondence | Total |
|---|---|---|---|
| 1949-1952 | 248 | / | 248 |
| 1953-1957 | 1708 | / | 1708 |
| 1958-1970 | 1073 | / | 1073 |
| 1971-1976 | 309 | / | 309 |
| 1977-1985 | 1485 | 530 | 2015 |
| 1986-1995 | 8173 | 3720 | 11893 |
| 1996-2000 | 5155 | 7264 | 8169 |

**Table 2**. The higher vocational level geomatics skilled talents cultivated by 1949-2000

### 2.2 Status

Since the 20th century, with the rapid growth of China's geomatics market demand, China's geomatics industry has promoted by formulating a numbers of favourable policies from the aspects of technological innovation, financial support and education development (Li et al., 2014). By the end of 2020, the output value of geomatics industry reached more than 689 billion RMB Yuan (CAGIS, 2020). In such circumstances, the demand for skilled talents (i.e. senior technician, technician, senior worker, intermediate worker and primary worker) grows rapidly. By the end of 2020, a total of 459025 skilled talents in China have obtained national geomatics vocational qualifications, including 81629 junior workers, 275772 intermediate workers, 95543 senior workers, 5,237 technicians and 824 senior technicians. More than three quarters of skilled talents obtained the qualifications in the past decade (Figure 1). At the same time, the demand growth of talents drives the development of geomatics VE, resulting in rapid growth of the scale of colleges.

By the end of 2020, 137 secondary vocational colleges, 254 higher vocational colleges and 2 ordinary universities had set up geomatics related disciplines, nearly doubling compared to 2010. More than 25000 geomatics skilled talents are sent to geomatics industry every year. About one-sixth geomatics skilled talents in China were cultivated by vocational colleges in the past five years. In terms of secondary vocational education, "engineering measurement technology" is the leading major offered by colleges, with an annual enrolment of about 7800. In terms of higher vocational colleges, "engineering measurement technology", "surveying, mapping and geographic information technology" and "Photogrammetry and remote sensing technology" are the leading majors, with an annual enrolment of about 15000. Geomatics VE has formed a good development trend of industry-college-research cooperation by constantly optimizing top-level design, innovating teaching mode and improving skill and practice, which has strongly supported the geomatics industry's demand for skilled talents.

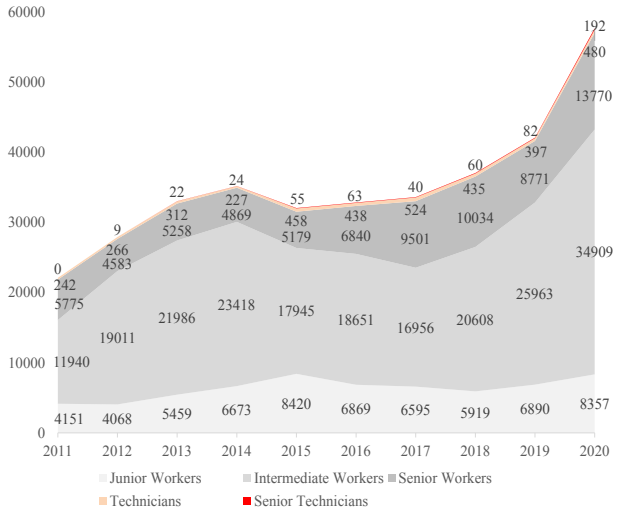


**Figure 1.** The number of skilled talents obtained the qualifications in the past decade

## 3. ISSUES AND PROBLEMS

### 3.1 The insufficient input of geomatics VE

Compared with general education, current geomatics VE developed late with a weaker foundation and a lower quality, especially reflected in the proportion of enrolment scale. In the past 10 years, the annual enrolment of geomatics VE continues to grow slowly, while general education enrolment has increased by more than 50 percent. In 2020, the annual enrolment proportion between geomatics VE and general education was 1:1.36, while the proportion in 2010 was 1:0.79. Especially in less developed areas, this proportion has fallen seriously in the past decade. Furthermore, there is a big gap between geomatics VE and general education in terms of funding investment. The funding for geomatics VE mainly comes from financial input and enterprise investment. Enterprise investment is an important part of worldwide geomatics VE. In Germany, one of the most developed countries of geomatics VE, the proportion of enterprise investment can reach 65%. Considering that the thinner profits of geomatics enterprises in China, the long-term lack of investment in geomatics VE continues to worsen. In addition, teacher staff, teaching facility and experimental equipment of geomatics VE are also inadequate. The imbalance between geomatics VE and general education will lead to the structural contradictions of labor force in China's geomatics industry.

### 3.2 The ambiguous orientation of geomatics VE

The boundary between geomatics VE and general education is relatively ambiguous, and the distinction and connection between geomatics VE and general education/vocational training are confused. On the one hand, some educators believe that geomatics VE is only a lower level than undergraduate and graduate education and place too much emphasis on the systematiceness and integrity of the geomatics knowledge structure (Yang et al., 2018). On the other hand, some educators think that geomatics VE is the same with vocational training and focus on the ability to operate instruments and equipment. These understandings lead to teaching of basic theoretical knowledge has been ignored and deviated from the goals of geomatics VE. The goal of geomatics general education is to build up a complete knowledge system, to find the shortcomings of theoretical system, and to promote the innovation of knowledge theory. However, geomatics VE is aiming at "Practice-Theory-Practice", and form the ability to perform tasks well.

### 3.3 The slowly updating of technical knowledge

In recent years, the transformation and upgrading of geomatics industry have shown obvious characteristics of cross-border integration and cross-disciplines. The rapid development of emerging information technologies such as big data, artificial intelligence, Internet of Things and block chain has made the geomatics industry developed in the direction of intelligence, automation, ubiquitous and real-time. The demand for intelligent processing, analysis and application, sharing and service of spatial data is increasing rapidly. The requirements of geomatics industry for skilled talents are developing from single to compound and extending from data production to application service. For example, aerial photogrammetry ranks first, accounting for about 1/3, and unmanned aerial vehicle (UAV) control accounts for 1/5 among the business areas that the surveyed company plans to expand in the next three years. However, more than half of the disciplines opened by VE colleges are "engineering surveying", and the proportion of "UAV surveying and mapping technology" is less than 5%. At the same time, professional educators have been in the front line of teaching for a long time. They only focus on their own familiar fields, lack of sensitivity to new things and not enough updating of geomatics technology, which leads to disconnection with advanced geomatics techniques.

### 3.4 The teaching staff needs to be improved

Teachers are very important to improve the quality of geomatics VE. Geomatics VE needs solid theoretical knowledge, rich practical experience, and three composite ability requirements of teacher, surveyor and engineer. The curriculum content is based on professional ability and condenses professional ability into ability standard, and then transforms it into teaching content. At present, the source channels of teachers for geomatics VE are relatively single. In higher vocational colleges, for example, about 80 percent of full-time teachers have master's degrees. Most of them are directly involved in teaching work after graduation, lacking a lot of engineering practice, and unable to directly integrate practical experience into classroom teaching and field practice. The courses taught are not targeted and lack practical guidance for working positions, at the same time, teaching methods and means lack of enough innovation. The students of geomatics VE generally have stronger practical ability, but poor abstract and deductive ability. Current teaching generally ignores this point, and fails to design appropriate learning situations according to training programs, objectives and contents, so as to cultivate students' habits of discovering, researching and solving problems.

### 3.5 An environment of open communication is urgently needed

At present, vocational colleges generally adopt the college-enterprise cooperation mode including mainly three ways: colleges hiring enterprise experts as practice instructors, enterprises accepting students for internship, and enterprises accepting graduates for employment. Few colleges run enterprises to promote the integration of industry and education. However, there are still some problems in college-enterprise cooperation, mainly including: (1) many enterprises only sign strategic cooperation agreements with colleges, and the follow-up cooperation is not fully implemented; (2) the number of cooperative enterprises is relatively small and cannot provide enough academic posts and practices; (3) many enterprises recruit scholars to produce projects for the purpose of cheap employment and lack long-term plans and programs to cultivate students; (4) the management and evaluation systems of college-enterprise cooperation are imperfect and have no supervision and restraint effect on the cooperation.
At the same time, full-time teachers lack time for academic exchange and ability improvement due to more and more courses and most of the energy is focused on completing the teaching task set by colleges, which has been a common problem in geomatics VE. For example, in recent years, seminar activities for geomatics VE are less and less.

## 4. RECENT DEVELOPMENTS

In response to the above issues and problems, extensive investigation has been conducted on competent departments, vocational colleges, enterprises, employees and students through questionnaire. Some reforms have been carried out on geomatics VE around discipline catalog, basic requirements and recommended curriculum standards. The teaching quality of geomatics VE is continuously improved by enriching teaching resources and building training platforms.

### 4.1 Discipline Catalog

The discipline catalog of geomatics VE is not only the guiding document for the national macro management for VE, but also is the main basis for geomatics vocational colleges to set up and adjust majors, formulate talent training programs and organize enrolment and employment. In 2019, the state issued the Implementation Plan for Vocational Education Reform, which requires discipline catalog should be revised every five years, and maintain a dynamic update each year. The last editions of the secondary and higher geomatics VE discipline catalogs were revised in 2010 and 2015, and has been published for 12 years and 7 years respectively. During this period, the geomatics industry has experienced rapid development and technological innovation, which leads to a certain deviation between the specialty setting of VE and industry demand for skilled talents.
The revision work of geomatics VE takes into account following factors.

**4.1.1 Up-down connectivity:** Disciplines at different levels should adopt an integrated concept to link up geomatics VE from top to bottom. From example, major of "aerial photogrammetry" in secondary vocational level corresponds to majors of "Photogrammetry and remote sensing technology" and "UAV surveying and mapping technology" in higher vocational level.

**4.1.2 Information-based upgrade:** New occupations derived from geomatics industrial and technological upgrading and transformation should be considered, including UAV operator, 3D geographic information collector, point of interest geographic information collector, geographic information modeller, navigation and location service operator, Internet map service operator, geographic situation statistical analyst, etc. For example, the majors of "UAV surveying and mapping technology" and "Spatial digital modeling and application technology" are set up due to the development trend of 3D visualization and UAV technology.

**4.1.3 Docking with new industry division:** According to the adjustment of national industry classification standards, the major of "engineering measurement technology" in secondary vocational level is adjusted from the category of "civil engineering hydraulics" to the category of "surveying, mapping and geographic information". The major of "territorial Planning and surveying" is renamed as "territorial space planning and surveying" due to the rise of space planning.

**4.1.4 Appropriate retention of majors in traditional areas:** Although the enrolment of "Geology and surveying" is difficult at present, the major is irreplaceable and still needs to meet the needs of geological prospecting industry.

The newly revised discipline catalog in 2021 is divided into three levels, with a total of 17 majors (Figure 2).

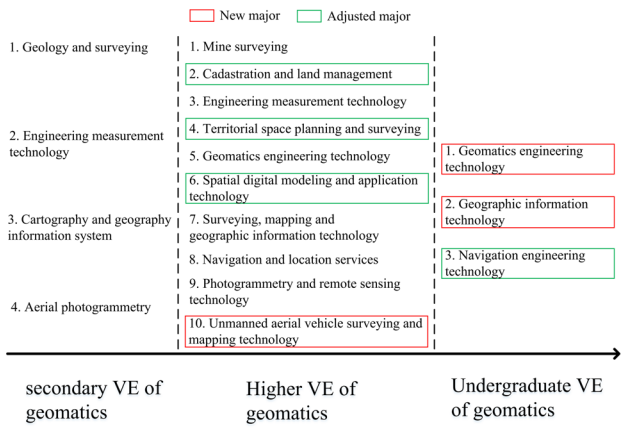


**Figure 2.** The newly revised discipline catalog in 2021

## 4.2 Objectives and Requirements

From primary to the highest level of geomatics VE, different levels correspond to different ability requirements (Figure 3). The goal of the first level is to train generally skilled personnel, who are required to master basic professional knowledge and the operation of geomatics instruments and equipments, and can play an important role in the team. The first level corresponds to secondary VE of geomatics. The goal of the second level is to cultivate team leaders, who are on the basis of the first level and also required to have some management and organizational abilities, as well as analyze and solve problems. The second level corresponds to higher VE of geomatics. The goal of the third level is to cultivate good engineers, who are able to design and manage project, control plan and schedule of projects implementation, and improve and optimize their own technical level through continuous learning. The third level corresponds to undergraduate VE of geomatics. The goal of the fourth level is to be an excellent engineer, who have excellent leadership, research and development ability and innovative spirit, and are able to coordinate different teams and projects at the same time. The fourth level corresponds to graduate VE of geomatics, but is still in the exploratory stage by now.

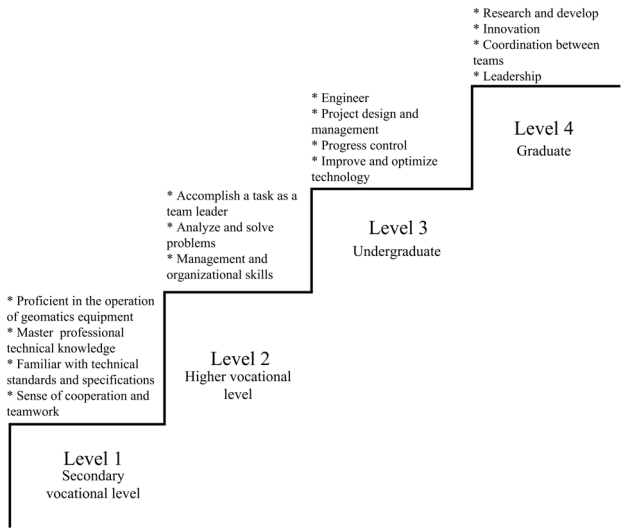


**Figure 3.** The competencies of different levels of geomatics VE

## 4.3 Recommended Curriculum Standards

Curriculum standards are the basis for teaching discipline concepts, knowledge systems and vocational skills, thus play a fundamental role in geomatics VE. At the same time of the new round of discipline catalog revision, the revisions of relevant curriculum standards are also officially started. The revisions of curriculum standards for each major have carried out investigation for the industry, enterprises, colleges, graduates and research and evaluation institutions, and comprehensively considered the factors of student quality, position professional quality, position ability demand, and position knowledge structure, etc.

This paper takes "aerial photogrammetry" in secondary vocational education as an example to illustrate the recommended curriculum standards. The curriculum of "aerial photogrammetry" should be finished within 3 years, including public basic curriculums, professional curriculums and practical teachings.

Public basic curriculums are compulsory stipulated by the state, with a total of 13 courses, including Chinese, mathematics, foreign language, history, mental health, etc. Colleges can offer public basic curriculums with local characteristics.

Professional curriculums include basic courses, core courses and expansion courses (Table 3). 4 basic courses, 6 core courses and 10 professional development courses are recommended. Colleges can independently determine the title of courses. According to the needs of project-based and modular teaching, basic courses, core courses and expansion courses can be organically reorganized, but the content must meet the standard requirements.

Practical teachings can be divided into integrated practical training and post internship, including practical training, experiment, graduation project and social practice. Integrated practical training is a compulsory curriculum. It is suggested to

arrange 6 teaching of practical projects combined with actual demand. Post internship is an essential practical teaching, which requires students to practice in the production and service line of the enterprises after completing the study of professional curriculums. The post internship usually takes place in the second or first semester of the third year and lasts no less than 6 months.

| Type of courses | Title of courses |
|---|---|
| Professional foundation courses | 1. Digital topographic survey<br>2. UAV aerial photography<br>3. Digital cartography<br>4. Basis of aerial photogrammetry |
| Professional core courses | 1. GNSS positioning measurement<br>2. Field work of aerial photogrammetry<br>3. Digital photogrammetry<br>4. Digital line graph editing<br>5. UAV measurement technology<br>6. UAV operation |
| Professional development courses | 1. Computer image processing<br>2. Physical geography<br>3. Geomorphology<br>4.Oblique photography and 3D modelling techniques<br>5. Engineering surveying<br>6. Real estate surveying and mapping<br>7. UAV assembly and maintenance<br>8. Control survey<br>9. Application cases of aerial photogrammetry technology<br>10. Land use planning |

**Table 3.** Recommended professional curriculums for "aerial photogrammetry"

### 4.4 Teaching Resources

In view of the resources imbalance of geomatics VE, the resources coverage of high-quality geomatics VE should be expanded by an information platform. This is can be achieved through the allocation of resources from vocational colleges and enterprises, the joint construction and continuous renewal of high-quality professional teaching and vocational training resources, and the sharing of high-quality resources between colleges and enterprises.

Taking the "Teaching Resource Database Platform of Geomatics Information Technology in Higher Vocational Education" as an example, the platform was established in 2018, passed the acceptance in 2020, and is now open to the society to provide services. Led by Yellow River Conservancy Technical College, the platform has been jointly built by 21 domestic higher vocational colleges, 1 secondary vocational college, 2 foreign well-known universities in the United States and Canada (Northwestern Michigan College and Fleming College), 15 well-known enterprises and 2 publishing houses.

By March 2022, the platform has set up 7 functional modules (Table 4). It provides rich contents in geomatics technology, management and teaching resources that can meet the needs of teachers, students and employees in autonomous learning, teaching organization, training and competition. It is remarkable that the platform has launched the vocational qualification certification curriculums for skilled talents. After completing the certification curriculums and tests, skilled talents can obtain professional qualification certification (Wang et al., 2020).

| Module | Content |
|---|---|
| Study center | 1. 32 standard curriculums<br>2. 10 personalized curriculums<br>3. 3 Training competition curriculums<br>4. 505 operation video curriculums<br>5. 13 skill points subjects<br>6. 28 technical lectures<br>7. 17 curriculum quality reports<br>8. 18 typical learning schemes<br>9. 19 online teaching standards<br>10. Vocational education cloud module |
| Material center | 1. 20687 material including texts, micro classes, graphics, audios, animations, videos, virtual simulations, web courseware, rich medium, etc. |
| Training center | 1. Professional qualification module<br>2. Professional certification module |
| Skill training center | 1. Skill training module<br>2. Excellent skill certification system<br>3. Skill Evaluation program |
| Skill competition center | 1. Student skill competition module<br>2. Employee skill competition module<br>3. Teacher skill competition module<br>4. Competition video library |
| Innovation and entrepreneurship center | 1. 13 Entrepreneurship curriculums<br>2. Innovation and entrepreneurship guidance module<br>3. Innovation and entrepreneurship competition module<br>4. Innovation and entrepreneurship cases |
| International center | 5. 23 coursewares in English<br>6. 72 bilingual teaching videos |

**Table 4**. The main modules and contents of the teaching resource database platform

### 4.5 Training Platform

**4.5.1 "1+X" certificate system**: "1" is the academic certificate, which reflects the training quality of vocational college education. "X" refers to several vocational skill level certificates, which reflects the vocational skill level of graduates and social members. The combination of academic certificate and vocational skill level certificate is an innovation reform of cultivation and evaluation of skilled talents (Zhang and Xia, 2022). At present, the system is still being piloted. Four skill certificates related to the geomatics industry, namely "Surveying and mapping geographic information data acquisition and processing", "Surveying and mapping geographic information intelligent application", "UAV photogrammetry" and "real estate data acquisition and database building", were selected into the list of pilot certificates in 2020. The current focus is to integrate professional standards into talent training programmes, curriculum development and textbook writing. By constructing primary-mediate-advanced level training course modules, the teaching resources lacking in "X" certificate are supplied. The primary module is a collection of geomatics professional basic courses. Mediate module is a collection of modular courses which is set up to deal with the trend of fuzzy professional boundaries and cross-border integration of technology. The advanced course module reflects the unique professional characteristics and helps students engage in professional work or academic study after graduation.

**4.5.2 Training bases:** It is divided into on-campus practice and college - enterprise cooperation training base, which plays an important role in the training teaching of geomatics VE (Zhang and Xu, 2020). On-campus training base is composed of laboratory and field training. At least one class shall be equipped with software and hardware equipment to meet the training requirements at the same time. Taking "aerial photogrammetry" in secondary vocational education as an example, conventional measuring instruments, geographic information acquisition and image processing software, UAV and simulator, ground workstation, 3D modelling and virtual simulation software are necessary, which can support the completion of field training projects such as topographic map graphic editing, UAV control, photo control survey, image annotation, digital line graph annotation, etc. College - enterprise cooperation training base is an effective way for students to quickly integrate into work place. Compared with the past model of mainly relying on geomatics enterprises outside the college, "enterprise in college" is more worthy of recommendation. The geomatics software and equipment facilities, professional standards and operating procedures, geomatics production tasks, team management atmosphere and market-oriented evaluation standards of the "enterprise in college" training base are seamlessly connected with the enterprise. At the same time, relying on the training base, students can start their own business in college and organize entrepreneurial teams to further train comprehensive qualities such as skills, organization and coordination.

**4.5.3 Skill competitions**: Geomatics vocational skill competition is a stage to show the ability level of skilled talents. It is of great significance to mobilize the enthusiasm in practice, test mastery level of basic knowledge, and improve practical operation ability for college students. The geomatics skill competition is divide into secondary vocational, higher vocational, undergraduate and adult groups, and set up levelling, digital topographic survey and survey program design and other projects. The competition results are comprehensively evaluated from the aspects of time, quality and calculation results. Considering the insufficient coverage of the existing competition projects, it can be considered to add UAV photogrammetry, GIS spatial analysis and other projects. In terms of competition methods, the combination of online and offline can be adopted, and basic knowledge items can be added to investigate the mastery level of knowledge.

## 5. CONCLUSION AND FUTURE OUTLOOK

China's geomatics VE has a long history and has experienced a tortuous development process. The paper overviewed the history and current situation of geomatics VE, and summarized the existing problems. In the past few years, the reform of geomatics VE has made good progress, which is of great significance to the development of geomatics industry.

Furthermore, China's geomatics VE still needs to be improved in many aspects. In the future, we propose to focus on the following parts: (1) continue to increase investment in geomatics VE in terms of funds, teacher staff and teaching facilities, so as to tilt all resources to geomatics VE; (2) enhance the social identity of geomatics VE; (3) broaden the rising space of geomatics VE students and expand the "Top-up Program" number of geomatics colleges; (4) carry out annual investigation on the demand for talents in geomatics industry, and guide vocational colleges to adjust and set majors; (5) expand the trial of "1+X" certificate system; (6) strengthen international cooperation in geomatics VE.

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## REFERENCES

CAGIS, 2020. *China Geospatial Information Industry Report(2020)*. Surveying and Mapping Press, Beijing.

Jia, D., 2013. Analysis of Personnel Training and Demand Forecast for Surveying , Mapping and Geoinformation of Domestic Colleges and Universities. *Bull surv map* (7), 112-114.

Li, D., Gong, J., Yue, P., 2014. Geoinformatics education in China. *Geo-Spatial Inf. Sci.* 17(4), 208-218. https://doi.org/10.1080/10095020.2014.985282

Shen, D., Xu, H., 2012. *Secondary Professional and Higher Vocational College Education in New China (1949-2000)*. Surveying and Mapping Press, Beijing.

Tang, G., Dong, Y., Jia, Y., Gao, Y., 2008. Geo-Spatial Information Technology Education in China, Present and Future. *ISPRS, Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. XXXVII(B6a)*, 5-10.

Wang, Q., Zeng, C., Dong, M., 2020. Innovative research on evaluation standard system of skilled talents on surveying and mapping geographic information industry. *Bull Surv Map* (9), 143-147. https://doi.org/10.13474/j.cnki.11-2246.2020.0302

Wang, S., Shi, Q., Wang, X., 2011. *The History of Chinese Surveying and Mapping Education*. Chinese People's Liberation Army Publishing House, Beijing.

Yang, W., Li, X., Liao, H., Li, T., Deng, J., 2018. On Talent Cultivation Mode of Engineering Survey Specialty Based on Typical Surveying and Mapping Project and Information Surveying. *J. Southwest China Norm. Univ. Sci. Ed*. 43(12), 146-151. https://doi.org/10.13718/j.cnki.xsxb.2018.12.023

Zhang, P., Xia, H., 2022. Study on the Theoretical Interpretation, Logical Framework and Promotion Suggestion of China's 1+X Certification System. *Tsinghua J. Educ*. 43(1), 78-86. https://doi.org/10.14138/j.1001-4519.2022.01.007809

Zhang, X., Xu, Y., 2020. Practice of the Construction of Multi Dimensional Training Base Based on the Integration of Industry and Education. *Digit. Print.* (09), 229-233. https://doi.org/10.19370/j.cnki.cn10-1304/ts.2021.04.015