

# Application of engineering- R&D integrated thinking mode for innovative talents cultivation of intelligent navigation experimental class

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**Abstract.** In view of the four prominent contradictions in the traditional engineering thinking teaching system of surveying and mapping engineering, which are difficult to meet the new requirements of innovative talents cultivation, a new talent training mode based on the integration of engineering and re-search thinking is proposed. Taking surveying and mapping engineering (intelligent navigation experimental class) as the research object, the multi-level training system of "thinking transformation - professional development - model transformation" was designed, and the reform and practice were carried out from the multiple links of "curriculum system - textbook construction - practical teaching - innovation credits". The teaching practice in the past four years shows that the integrated thinking mode of engineering and research has been well applied in the cultivation of innovative talents in the intelligent navigation experimental class, and has achieved remarkable results in many aspects, such as the improvement of innovation ability, the promotion of teaching and practice system, the construction and application of teaching materials, and the development of disciplines and specialties, laying a solid foundation for the output of top innovative talents in the intelligent navigation experimental class.

## 1 Introduction

The surveying and mapping engineering specialty of Beijing University of Civil Engineering and Architecture (BUCEA) has a long history of running school. It has long adhered to the professional construction concept of keeping pace with the times and the teaching reform idea of adhering to the characteristics of "urban + architecture" surveying and mapping specialty and has cultivated a large number of out-standing talents in the field of urban construction in the capital and even the whole country with the goal of improving innovation ability.

In recent years, because new concepts such as engineering certification, new engineering subjects and national teaching quality standards have been put forward [1-4], and new technologies such as BDS, artificial intelligence, internet +, big data have developed rapidly [5-7], the traditional engineering thinking teaching system of surveying and mapping engineering is difficult to meet the new requirements for cultivating innovative talents, mainly facing the wide range of knowledge required for surveying and mapping talents and the lack of key courses in the existing syllabus. The rapid development of new technology and the slow updating of teaching materials, the great difficulty in teaching the development of researching and the lack of practical innovation platforms, the systematization of innovative and entrepreneurial talent cultivation and the fragmentation of the existing teaching system are four prominent contradictions. Under

the current two-wheel driving background of new concepts and new technologies, it is urgent to actively promote the innovation of the thinking mode of talent cultivation in surveying and mapping engineering. This is also a teaching problem that needs to be solved urgently in the comprehensive re-form of talent cultivation based on traditional engineering thinking [8-9].

Based on this, BUCEA actively promoted the transformation of the discipline thinking of surveying and mapping engineering from a single engineering thinking to a new thinking mode of integrating engineering-R&D (Research and Development) thinking. By expanding the extension of the direction of intelligent navigation of surveying and mapping engineering, the first surveying and mapping engineering specialty (intelligent navigation experimental class) was opened in 2019. It also focuses on the theoretical and practical teaching reform around the multiple links of "curriculum system, textbook construction, practical teaching, and innovative cred-its".

After four years of professional construction and practical innovation, 7 provincial and ministerial level and 3 university and bureau level educational reform projects were established, a new mode of talents cultivation for surveying and mapping engineering (intelligent navigation experimental class) based on the integration of engineering and research was constructed, new ideas and new ways of innovative talents cultivation for intelligent navigation experimental class were proposed, new curriculum syllabuses were prepared, and talent training

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programs for intelligent navigation experimental class were optimized year by year. Solve the outstanding contradictions in the traditional teaching and practice of surveying and mapping engineering under the background of new concepts and new technologies, improve the innovation ability, increase the proportion of graduates entering the employment of navigation product R&D enterprises, broaden the development space of surveying and mapping engineering students and effectively support the development of surveying and mapping disciplines and the construction of national first-class majors.

The structure of this paper is as follows. Firstly, it introduces the construction idea of the integrated thinking mode system of engineering and research, and then explains the implementation path and method. Then, it shows the current application results and evaluation. Finally, the corresponding conclusions are summarized.

## 2 Thoughts on the construction of the integrated thinking mode system of engineering and research

In view of the current two-wheel driving background of new concepts and new technologies, the traditional engineering thinking teaching system of surveying and mapping engineering faces four major contradictions, which is difficult to meet the new requirements of innovative talents cultivation. Based on undertaking 7 provincial and ministerial level and 3 university and bureau level educational reform projects, this paper designs a multi-level training system of "thinking transformation - professional development - model change", and carries out reform and practice from multiple links of "curriculum system - textbook construction - practical teaching - innovation credit", and proposes a talent training system based on the integrated thinking mode of engineering and research [10-16], as shown in Figure 1.

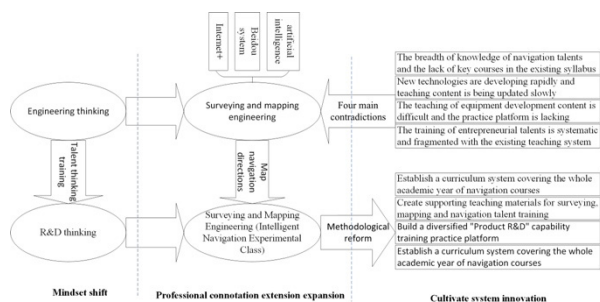


Fig. 1. Talent training system based on the engineering-R&D integrated thinking mode.

It can be seen from Figure 1 that the overall design of the talent training system based on the integrated thinking mode of engineering and research mainly includes three levels: first, the talent thinking is changed from single engineering thinking to integrated thinking of engineering and research to realize the thinking transformation; Secondly, the direction of intelligent navigation has been expanded from traditional surveying and mapping engineering to surveying and mapping engineering (intelligent navigation experimental class), and the

extension construction of surveying and mapping specialty has been expanded; The last is the innovation of training system. In view of the four major outstanding contradictions, we will focus on the reform and practical innovation of the method system in the four aspects of "curriculum system, textbook construction, practical teaching and innovative cred-its". The construction of talent training system based on the integrated thinking mode of engineering and research is as follows:

(1) Establish a curriculum system covering the whole academic year of intelligent navigation course, add courses related to navigation theory development, broaden the teaching content, and meet the needs of economic and social development for intelligent navigation innovative talents.

(2) Create supporting teaching materials for training intelligent navigation talents, strengthen the ability to solve complex engineering problems facing mapping and navigation through innovative teaching material compilation concepts, and reflect the high-level nature of the intelligent navigation direction teaching material system.

(3) Build a practice platform for the training of diversified "engineering - R&D" integrated thinking ability, carry out in-depth engineering -education integration through school-enterprise cooperation and collaborative education, and create a di-versified practice teaching platform with innovative smart city navigation and location service features.

(4) Establish an innovative credit system teaching system with seamless connection between in-class and extracurricular/innovation and entrepreneurship, implement the all-through tutorial system for undergraduate students, set the talent training challenge of integrating engineering- R&D thinking, and implement the mechanism of teaching students according to their aptitude.

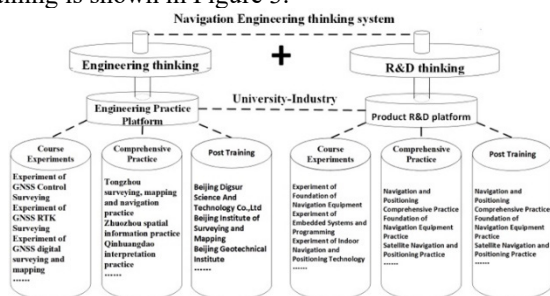
## 3 Implementation path and method

Under the background of new concepts and new technologies, the traditional engineering thinking teaching system of surveying and mapping engineering is difficult to meet the new requirements of cultivating innovative talents for intelligent navigation, which is also an urgent teaching problem to be solved in the current comprehensive reform of surveying and mapping engineering. Therefore, the reform of problem-oriented talents cultivation mode is bound to promote the exploration and practice of innovative talent training mode in the intelligent navigation experimental class. The implementation path and method of the integrated thinking mode of engineering and research include:

(1) Broaden the teaching content and establish a curriculum system covering the whole semester year of navigation course. In order to effectively solve the shortcomings of the wide range of knowledge of surveying and mapping navigation talents and the lack of key courses in the existing syllabus, centering on the requirements of the engineering certification standards of the surveying and mapping engineering specialty, adhering to the national



(3) The school, enterprise and engineering are deeply integrated to build a practical platform for the training of diversified "engineering research and development" integrated thinking ability. The traditional practical teaching system of surveying and mapping engineering specialty is a practical training platform based on a single engineering thinking engineering ability. Through the establishment of university-enterprise engineering - learning cooperation and the in-depth integration of engineering and education, it focuses on the two levels of engineering practice ability (engineering thinking) and development ability (research and development thinking) of intelligent navigation innovative talents, as well as the three levels of "course experiment, comprehensive practice, and on-the-job training". The diversified "engineering R&D" practice platform integrating thinking ability training effectively solves the teaching problems of the difficulty in teaching the development content of intelligent hardware equipment products and the lack of practical innovation platform. First, establish a "going out" mechanism, and jointly establish off-campus internship and training bases with Beijing Zhongke Zihuan Information Technology Research Institute, State Grid Siji Location Service Co., Ltd., Zhonghaida and other enterprises; The second is to establish a "invite in" mechanism, hire corporate mentors, meet the needs of the practical teaching system for the cultivation of innovative talents in intelligent navigation, establish an experimental platform for 13 courses, five comprehensive practice bases, and jointly establish a training and teaching base with five enterprises. The practice platform of the diversified "engineering R&D" integrated thinking ability training is shown in Figure 3.



**Fig. 3.** Platform of diversified "integration of engineering and research" thinking ability

(4) Establish an innovative credit system teaching system with seamless connection between in-class and extracurricular/innovation and entrepreneurship. In view of the fragmentation of innovation and entrepreneurship in the traditional teaching system and the lack of systematic connection between in-class and out-of-class, creatively increase the innovation credit value and set a minimum of 6 innovation credits (of which, at most 5 are optional in class and at least 1 is optional outside class). First, set up the innovation training practice system for scientific research teams, and set up the training of navigation basic R&D ability, the training of navigation system development ability, the training of team cooperation and innovation and entrepreneurship ability, the training of surveying and mapping skills competition, the training of surveying and mapping program design

competition, and at most 5 in-class innovation credits, as well as the national/Beijing municipal/university level surveying and mapping intelligent innovation and entrepreneurship competition, Beidou innovation and entrepreneurship competition. At least one extracurricular innovation credit can be selected from the navigation and positioning terminal embedded program design competition, the "Beidou Cup" National Youth Science and Technology Innovation Competition and various discipline competitions; The second is to promote innovative credit learning into the classroom (practical training of mapping skills contest, practical training of mapping program design contest), scientific research and innovation training team (practical training of navigation basic R&D ability, practical training of navigation system R&D ability, practical training of team cooperation and innovation and entrepreneurship ability), discipline competition (mapping intelligent innovation and entrepreneurship competition, etc.), and entrepreneurship (Beidou Innovation and Entrepreneurship Competition, "Youth Creation", "Challenge Cup", etc.), Complete 10 sets of practical teaching syllabus for undergraduate scientific research training and innovation credit system; The third is to implement the full penetration tutorial system for undergraduate students, put forward the full penetration of innovation credits every semester, and all the students will enter the research group of the tutor's scientific research team. At the same time, enterprise mentors will be invited to participate in the innovation and entrepreneurship education for college students, carry out the whole chain of innovation and entrepreneurship scientific research training, create a new mode of in-class, out-of-class, innovation-enterprise talent training, and establish the innovation credit course in the innovation training course of scientific research teams. Put the innovation credits of programming ability training into the curriculum, and optimize and improve the original innovation and entrepreneurship ability training system mainly based on the discipline competition training mode, relying on the linkage talent training mechanism of the "National/Beijing City/University-level Surveying and Mapping Intelligent Innovation and Entrepreneurship Competition" and taking "academic papers, invention patents, software registration" as the result output orientation of innovation credits, Guided by the innovation and entrepreneurship competitions such as "Challenge Cup, Internet plus, and Innovation Youth", the competition promotes learning. Through innovation credits, the hub between in class and out of class, innovation and entrepreneurship is established, creating a seamless connection system between in class and out of class/innovation and entrepreneurship, and further deepening the deep integration of professional education and innovation and entrepreneurship education; Fourth, enterprises provide demand and scientific research funds, build entrepreneurship platforms, and provide students with entrepreneurship environment. The established in-class/extracurricular/innovation-enterprise seamless connection innovation credit system teaching system is shown in Figure 4.





**Fig. 4.** Innovative credit system teaching system with seamless connection between in-class, extracurricular, innovation and entrepreneurship.

## 4 Application effect and evaluation

After nearly four years of professional construction and teaching practice, it has been shown that the integrated thinking mode of engineering and research has been well applied in the training of talents in the intelligent navigation experimental class, and has achieved remarkable results in four aspects, including the improvement of innovation ability, the promotion of teaching and practice system, the construction and application of teaching materials, and the development of disciplines and professional construction.

### 4.1 The innovation ability has been greatly improved

Under the evaluation of engineering certification standards, the teaching quality of all staff reached the standard, and the "engineering research and development" integration thinking ability was greatly improved. Students won 3 prizes in the Challenge Cup, Internet plus and other national competitions, as well as 4 special prizes, 6 first prizes, and 10 second prizes in the national college surveying and mapping intelligent innovation and entrepreneurship competition; Obtained 18 authorized invention patents and 8 software copyrights, and published 12 academic papers; The success rate of graduates (including going abroad for further study) has reached nearly 40%, and the employment rate of enterprises related to navigation has been further improved.

### 4.2 The teaching and practice system has been widely promoted

The practice teaching system of diversified "engineering - R&D" integrated thinking ability training has been popularized and applied in 11 engineering majors in 6 disciplines in the university. In addition to surveying and mapping majors, it also plays an important demonstration role in the practice teaching system of many non-surveying and mapping majors, such as architecture, civil engineering, transportation, urban planning, landscape architecture, environmental science, environmental engineering, engineering management, engineering cost, etc. The talent training system and relevant teaching practice experience based on the integration of engineering and research have strong demonstration and popularization and have been well promoted and applied in many universities in China, directly benefiting more than 2000 students.

### 4.3 Abundant achievements in textbook construction and application

It has set up seven provincial and ministerial level and three university and bureau level educational reform projects and has been rated as a Beijing excellent undergraduate education team. With the guiding ideology of "optimizing the content, highlighting the core, and updating in time", it advocates the teaching material compilation concept of "knowledge skeleton - practice cases - student knowledge structure". It has published five navigation supporting textbooks, one practical training textbook, and two trial handouts. Among them, the Principles and Applications of Satellite Positioning and its supporting training materials have been printed three times in the past six years, with an annual sale of more than 1000 copies, which have been applied in many colleges and universities across the country and are listed as reference books for postgraduate and doctoral examinations by many colleges and universities.

### 4.4 Strongly support discipline and professional development

The integrated thinking mode of engineering and research has been well applied in the training of talents in the intelligent navigation experimental class, which strongly supports the development of advanced and sophisticated surveying and mapping disciplines and the development of national first-class professional construction sites. In 2018, the discipline of surveying and mapping science and technology was awarded the title of Beijing's advanced and sophisticated discipline, and the surveying and mapping engineering specialty passed the re-evaluation of the engineering education professional certification with high quality, and promoted advanced experience in the national surveying and mapping universities; In 2019, the major of surveying and mapping engineering was selected as the first batch of national-level first-class professional construction sites, and was rated as one of the Beijing municipal virtual simulation experiment teaching platforms. The first session of surveying and mapping engineering (intelligent navigation experiment class) was creatively opened. The Department of Navigation Engineering was established in 2021, and the major of navigation engineering was newly established, and 35 students were recruited for the first time in 2022. At present, the intelligent navigation experimental class has been enrolled for four consecutive times and has attracted the attention of the majority of examinees and parents during the reform of high school enrollment in Beijing from 2019 to 2022. Relevant achievements won the first prize of Beijing Higher Education Teaching Achievement Award in 2022.

## 5 Conclusion and prospect

Taking surveying and mapping engineering (intelligent navigation experimental class) as the research object, this paper designs a multi-level training system of "thinking transformation - professional development - model

transformation” and constructs a new talents cultivation mode based on the integrated thinking of engineering and research from the multiple links of "curriculum system - textbook construction - practical teaching - innovation credits". The teaching practice in the past four years shows that the integrated thinking mode of engineering and research has been well applied in the cultivation of innovative talents in the intelligent navigation experimental class, which has innovated the traditional engineering thinking teaching system of surveying and mapping engineering, and has better solved the problems of the wide range of knowledge required by surveying and mapping navigation talents and the lack of key courses in the existing syllabus, the rapid development of new technology and the slow updating of teaching materials, the great difficulty in teaching the content of researching development and the lack of practical innovation platform. Four teaching problems, such as the systematization of innovation and entrepreneurship talent cultivation and the fragmentation of the existing teaching system, have achieved remarkable results in many aspects, such as the improvement of innovation ability, the promotion of teaching and practice system, the construction and application of teaching materials, and the development of disciplines and specialties. They have laid a solid foundation for the output of top-notch innovative talents in the intelligent navigation experimental class and have important practical guiding significance.

It is worth mentioning that in the next stage, we will timely summarize the experience of running the intelligent navigation experimental class, adhere to the concept of continuous improvement, further improve the service capacity of Beijing's high-end and sophisticated industries and the innovative talents cultivation needs to break through the "bottleneck" key technology of our country in the process of talent training, and deliver a higher level of intelligent navigation talents for the national development.

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