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Development of the *"1+2+X"* Modular Course System for Information Technology Majors from the Perspective of Dual-Mode IT

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Abstract

As the third generation of IT is developing rapidly, higher education institutions in China are looking to produce innovation-minded talent who can adapt to the dual-mode IT work environments of modern enterprises to meet the demands of the intelligent manufacturing national development strategy. So, this research aims to specify the hierarchical talent training system and mechanism for information technology majors in the higher education system. A 1+2+X modular curriculum system was proposed for the information technology majors based on the group-chain development model that focuses on combining discipline and industry (also known as vertical and horizontal integration). The data analysis was performed through a comparative analysis of the talent training objectives of the Chinese institutes and course systems' national development strategies. The results support the idea that the 1+2+X modular curriculum system can help universities produce innovation-minded talent by designing their curriculum based on the industry and trends rather than just focusing on specialization training. The novelty of this research is that it promotes the idea of professional development along with course training. This paper recommends that future researchers implement the concept in vocational institutes.

Keywords:

Dual-mode IT;
Information Technology Major;
Education; Curriculum System;
"1+2+X" Modular Course System.

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1- Introduction

The demand for talent from information technology (IT) majors, including computer science and technology, software engineering, and information systems, is extremely high. At the same time, with the popularization of the third generation of IT, including cloud computing and social media, big data, and mobile internet, the establishment of dual-mode IT has greatly promoted the transformation of enterprises into technology-driven applications [1]. Enterprises in China continuously increase their demand for innovative IT talent from higher education institutions [2]. Considering the industry's needs and requirements, the Chinese government set up a "Made in China 2025" strategy that calls for all the researchers in China to integrate new technologies into the higher education system to get on-demand talent in the manufacturing industry in China to a higher level and help the comprehensive development of its quality. As the Ministry of Industry and Information Technology stated at the meeting "Special Action for Intelligent Manufacturing Pilot Demonstration," intelligent manufacturing would become a major trend and a source of core content in the future, so the researchers should investigate the matter of implementing an intelligent manufacturing strategy through designing talent training systems in the higher education institutes. Implementing the intelligent manufacturing strategy has greatly

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increased the demand for producing more data-driven talent for enterprises from the traditional IT majors in universities and colleges [3]. Developing data-driven talent with innovation capability is crucial to meeting the enterprise's dual-mode IT and intelligent manufacturing requirements concerning skills and knowledge [2]. Previous studies reported that universities in China and enterprises could better pave the way for emerging engineering education, which should be further explored [4].

Previous literature pointed to three main approaches for producing technology-driven talent. First is curriculum system construction and research from the perspective of engineering education accreditation. Second is curriculum system construction and research under the background of new engineering construction, and third is curriculum system construction and research in undergraduate colleges. The research paper adopted the third approach, which provides guidelines for developing and researching the curriculum system. It was also found that the researchers should pay more attention to engineering education by focusing on redesigning the curriculum, considering vertical and horizontal integration with the industry [3]. After the literature review, the authors feel that although the existing practice and research on curriculum system construction are extensive and rich in content, until now, little or no studies have been done on producing technology-based talent in China.

This paper aims to fill the gap by proposing the 1+2+X modular course system with 1 basic course module in the discipline, 2 basic course modules in the major, and X multiple industry-oriented course modules for higher institutes in China. This concept optimizes the course system to shift talent training directly to the application and dual-mode IT development that meets intelligent manufacturing requirements.

The paper is structured into eight different sections. Section 1 provides the introduction; Section 2 reflects the literature review; Section 3 discusses the theoretical aspects of the study; Section 4 talks about the detailed methodology process adopted for the two sample universities for developing the concept of the 1+2+X modular course system; Section 5 addresses the details about the 1+2+X modular course system construction principles; and Sections 6, 7, and 8 present the characteristics of the 1+2+X modular course system discussion and conclusion.

2- Current Research Situation

2-1- The Implication and Function of the Curriculum System

The term "curriculum system" was introduced in the 1970s. As early as 1973, a standard curriculum system was established by American scholars for primary and secondary education. Concerning its connotation, the definition of a curriculum system includes broad and narrow senses [4]. The curriculum system was defined as "the process of mutual division and cooperation of all courses arranged according to the teaching plan," a broad understanding of the concept. It was emphasized that there was organization and coordination among courses, more like a system. The narrow sense of the curriculum system refers to the curriculum structure [5]. More researchers have defined a curriculum system at the meso-level: a knowledge combination system with specific functions, a fixed structure, and openness. It should use professional basic courses, theory, professional technology courses, professional applications, and training courses to form an interconnected and unified whole [6].

The definition of the curriculum system shows that it is complicated. Each course cooperates while retaining its own division of labor, which jointly promotes the quality of professional talent training. In recent years, developing effective curriculum system construction has been not only a hot spot for curriculum reform in higher education but also a key link in curriculum teaching reform in higher education. It is a significant driving force for process integration and optimization, textbook construction, faculty construction, and cooperation between schools and enterprises. It is beneficial to entrepreneurship education and the optimal allocation of teaching resources.

This study attempts to facilitate construction and research, and only a narrow aspect is considered, the mutual structure of courses. The "1 + 2 + X" modular curriculum system is formed to boost the training quality for IT professionals through the analysis, planning, and setting of relationships between the combinations of various courses.

2-2- Literature Review of Curriculum System Construction

Based on the current research, the curriculum system construction for IT majors is mainly reflected in the construction and research of professional curriculum systems with engineering education and a background in engineering professional certification. It also includes the professional curriculum system with a new engineering construction background, the curriculum system construction, and the research of engineering majors in undergraduate colleges.

2-2-1- Construction and Research on a Professional Curriculum System for Engineering and the Engineering Professional Certification

Professional studies in engineering professional certification are mainly conducted around "outcome-based education (OBE)." Educators must set clear expectations for abilities and levels and encourage students to achieve them when they

graduate through an appropriate educational structure [7]. The requirements for developing the curriculum in this field can be traced back to the Grinter Report proposed by the American Engineering Education Evaluation Committee. This report divides the courses of engineering majors into seven curriculum categories, including basic science, engineering science, and engineering analysis and design, and it pioneered the curriculum system for engineering majors. The report's greatest contribution is its fundamental role in forming the engineering curriculum system [8]. The research on engineering education and its practice requires that its teaching and curriculum be combined with engineering practice, which is also the main purpose of developing the professional curriculum system in the engineering field [9]. The Federation of European Engineering Associations (FEANI) has also contributed to the formation and standardization of the engineering curriculum system. It divides the curriculum into basic science, engineering, and nontechnical subjects [10]. In Canada, although engineering education is still gradually developing in many aspects, there are also many requirements for courses and students. For example, experiential learning, interdisciplinary ability, and serving social and environmental needs are requirements [11]. A systematic review of the engineering education research in Canada from 2004 to 2017 reflects that the engineering education research mainly focuses on the engineering education practice [12].

In addition to European and American countries, other countries are also rich in research on and construction of "engineering education" and "engineering education professional accreditation." The construction of the engineering education system in Russia can be traced back to the Kuznetsov Naval Academy and other schools built by Peter the Great in 1701. During the Soviet Union, Russian engineering education achieved a decisive breakthrough, and the education of mathematics, natural science, and technology was greatly developed. Today, Russian engineering education has gradually entered the education mode of elite talents, mainly training "development engineers" and "R&D engineers." The main task of teaching is to deepen the existing knowledge in engineering and cultivate innovative ability, which is a special idea for engineering education [13]. The leapfrog development of higher engineering education in Brazil is the result of the comprehensive reform of the education system by the Brazilian government in the mid-1960s, which ultimately contributed to the improvement of the Brazilian industrial system. So far, the setting of engineering majors in Brazilian universities is mainly based on university courses and adjusted according to social needs, which broadens the setting of majors and the cultivation of talent diversity and, accordingly, pays attention to the cooperation between engineering colleges and enterprises. Brazil's engineering education experience obviously pays more attention to combining discipline and practice [14]. As the most populous country in Asia, India attached great importance to developing engineering education to revitalize the national economy and promote social development at the beginning of independence. After the 1990s, India developed an international professional certification system, which made it known as one of the countries with the best engineering education. In 2016, the scale of engineering education in India accounted for about 14.28% of the total scale of engineering education in the world. Its way of promoting the development of engineering education on a large scale is also a developmental idea suitable for developing countries in engineering education [12, 15].

In China, some scholars, from the perspective of the engineering domain ontology, divided engineering into six conceptual platforms, such as basic engineering, engineering field, and engineering activity, which provides a new way to divide the engineering curriculum structure [16]. Based on the perspective of engineering education accreditation, it is proposed to follow the three principles of reverse design, positive implementation, and continuous improvement" for the curriculum system construction of material forming and control engineering [17]. It also puts forward a professional curriculum system construction, which meets the requirements of engineering education certification. It emphasizes the core principle of "promoting construction by evaluation and continuous improvement," with the specialty of building electrical and intelligent systems as the core [18]. Also, based on the perspective of engineering education certification, the curriculum system construction idea of "general knowledge extensive majors" is proposed at the school level [19]. From the above thoughts, based on the aspects of engineering professional certification, it can be seen that the curriculum system concerned with engineering involves the cognition of the knowledge and discipline systems and emphasizes the practical engineering value of the courses offered.

2-2-2- Construction and Research on a Professional Curriculum System in New Engineering

A new engineering discipline refers to one that is being formed or will be formed. Its characteristics include being a leading force, combining ideas, being innovative, cross-border, and developmental [20]. The curriculum system construction in the new engineering mainly includes general and professional education. General education includes a basic curriculum group and a professional discipline curriculum group. The latter includes a professional core curriculum and a professional development curriculum group. It emphasizes the modularization of the curriculum; that is, the whole curriculum system comprises several complete curriculum modules. It can not only realize the integration of multiple cross-courses but also satisfy the needs of students. It has strong adaptability, openness, and practicability [21]. The thinking in developing the new engineering pays great attention to the knowledge system of cutting-edge and cross-engineering disciplines and the transmission and development of the discipline system, which is more in line with China's engineering talent training requirements in the new era.

2-2-3- Construction and Research on the Curriculum System of Engineering Majors in Application-oriented Universities

By transforming and developing local undergraduate colleges into application-oriented universities, such universities have also become an important topic in professional curriculum system construction and research. The concept of the curriculum for application-oriented universities includes paying attention to the mastery of the basic structure of disciplines and developing students' knowledge (structuralized curriculum concept) [22], application-oriented research topics, integrating the advantages of knowledge-based and skill-based disciplines [23], work process-oriented disciplines [24], and professional ability-oriented disciplines [25]. Because of the curriculum reform conducted by application-oriented undergraduate colleges around the core of "application ability" [26], the professional core curriculum system [27] is implemented, emphasizing the combination of discipline and applications.

Like domestic application-oriented undergraduate colleges, foreign communities and vocational universities have also developed curricula and researched engineering majors' curriculum systems. The curriculum system of American community universities has been extensively studied, and it is believed that it has the characteristics of the unity of freedom and flexibility, the compatibility of academics and professionals, and the combination of cohesion and development [28]. For example, it has been believed that an increasing number of American colleges and applied universities have begun to redesign the curriculum system to strengthen their abilities to provide services to industry and society and promote students' learning by creating a "guiding path" [29]. American colleges provide a strong link between helping students complete their studies and supporting economic development [30].

In conclusion, when examining the three perspectives of more concentrated discussion on professional curriculum system construction in universities, they all emphasize combining discipline and industry, theory and practice, and classical theory and innovative development. The "1 + 2 + X" curriculum system discussed in this paper includes both theoretical knowledge in the discipline and professional theoretical knowledge. It also includes a comprehensive curriculum system for industry development frontier and practical skills.

2-3- Overview of the Studies on the Information Technology Course System Construction

Research on the course system construction for IT majors conducted by national and foreign scholars can be classified into four categories:

First, there is research on engineering education certification. Based on the analysis of educational practice in China, a conceive, design, implement, and operate (CDIO) course program system was adopted for talent training in computer science and technology based on the requirements of engineering education certification standards and combined with the application-oriented talent objective orientation of schools [31]. A new course system was constructed to focus on cultivating students' diverse abilities, supported by teacher teamwork and cooperation, linked by the logical connection between courses, driven by teaching reform development, and initiated by teaching quality improvement. Based on the CDIO concept of engineering education, the construction of information science under the guidance of this concept should be reformed from the aspects of teaching organization and implementation, evaluation system, etc. The second category is research on the orientation of computer and management courses at home and abroad [32]. The orientation for course construction for IT majors is different in different countries and universities [33]. For example, the courses at Loughborough University in the United Kingdom are referred to as the computer information management major, focusing on the cultivation of computer skills. The courses at the University of London and Aberystwyth University are referred to as the business information management major, focusing on enterprise management theory; and the core course for the IT majors in the United States attaches importance to library information, focusing on the structure and management of library resources. Due to the differences in the courses of IT majors at different universities, it is always difficult to determine the management ratio and computer courses in the course system construction for information management majors, which may lead to low practicability of the courses. Third, there is research on project-driven and action-oriented teaching. Establishment of a software engineering course group as an example: some Chinese scholars proposed a course group construction scheme based on a "project team" and combined it with the teaching team, teaching reform, project-driven teaching, and quality evaluation [34]. Fourth, there is research on market demands. Realizing the background of intelligent manufacturing in China and the transformation and upgradation of the service manufacturing industry, the idea and practical experience of the curriculum system construction of mechanical and electronic engineering are put forward [35].

Based on research on data-driven engineering technology talent and its training problem in manufacturing informatization in China, other Chinese scholars put forward a professional talent training program, emphasizing the different-level talent demands of manufacturing informatization. This research establishes different data-driven talent training programs based on different informatization majors and realizes the joint teaching of specialized common knowledge and the special teaching of characteristic specialized knowledge by developing different course teaching systems and practice teaching systems [36]. There are also some Chinese scholars proposed that based on the trend of industry and education integration and collaborative education, application-oriented universities should take emerging

engineering education construction as an opportunity concerning international engineering education certification standards and take students as the centre to cater to the requirements of local industrial development, strengthen industry and education integration as well as cooperation between schools and enterprises, construct a collaborative technology innovation platform, construct an innovation and entrepreneurship platform jointly with the government and enterprises, explore the path of construction of the computer science to adapt it to local application-oriented university development, promote the deep integration of interdisciplinary majors, and explore the construction of open and shared emerging engineering education, which is the key to the connotative development of the construction of the computer science [37]. The latest concepts also proposed that the construction of a new generation of IT majors is required to construct a curriculum system of "platform + direction + project practice" to promote the quality of talent training to a new level [38].

In conclusion, these studies have analyzed the course systems of IT majors from different perspectives and proposed solutions based on engineering certification, meet market demands, and follow project-driven teaching to solve the current problems regular higher education institutions face. However, at present, there is no overall research and unified planning on the course systems of different majors in the two disciplines of computer science and management, and careful consideration of the superior resources of the two disciplines can not only make rational use of teachers, disciplinary knowledge, etc. but also form a multidisciplinary teaching team, promoting each other and achieving sound development. Starting from the theoretical course system and the practical course system, this research forms a set of talent training plans for IT majors with the characteristics of the times and majors, especially the 1+2+X modular course system, which provides a four-year talent training plan in universities and standards for training of IT majors.

2-4- Existing Problems in Course System Construction

Research on course system construction for IT majors conducted by national and foreign scholars can be classified into four categories:

2-4-1- Unclear Guidance

The so-called "guidance" refers to the overall objective and orientation of course system construction. Course system construction in higher education must be rooted in the discipline, serve the discipline's majors, and be market-oriented. However, the existing course system construction either meets the OBE concept of engineering education certification [39], focuses on emerging engineering education [40], or only serves regional industries [34]. The wide variety of objectives and orientations makes the guidance of the existing course system very confusing, the objectives of course construction are unclear and constantly changing; the construction stability is weak; and causes a lack of continuous and clear guidance. Only by clarifying the course system construction guide can the direction of its construction be specified.

2-4-2- Weak Sense of Timeliness

With the emergence of the Industry 4.0 era and Internet+, various disciplines, especially the IT industry, have developed rapidly and stunningly. However, the course content is outdated for course system construction in higher education. For example, less content related to "big data and artificial intelligence" is reflected in the courses of IT majors in higher education. On the other hand, the course setting structure is irrational, the training objectives are not well sorted out, there are still many "outdated and outmoded" technologies in courses, and the course structure is separated from the industrial technical structure, so it is difficult to realize the training objectives in training programs. The content of a single course cannot be updated in a timely manner, and the whole course system cannot keep up with the rapid technological development in the industry, so the latest achievements in disciplines and industries cannot be used in teaching. The whole course system lacks a sense of timeliness, and the cutting-edge course contents need to be increased.

2-4-3- Unclear Pertinence

Although the existing research on course system construction has revealed many basic science courses and basic professional courses, there are few courses and teaching contents in cutting-edge technologies based on market demands in various fields in all industry sectors and few courses for new technologies. The course system and structure lack pertinence to the in-demand job skills, job posts, job markets, and prospects in industries, etc., but place too much emphasis on basic knowledge and abilities. Therefore, students have difficulty quickly adapting to specific job requirements after graduation, and enterprises still need to spend more time, financial resources, and material resources on "secondary training" for graduates. For example, a course system should be constructed from the perspectives of job skills, job posts, and course integration, focusing on solving the practical problems to address the course system's lack of pertinence and training in practical skills and promoting direct support in the aspects of courses, job posts, and skills [41].

2-4-4- Weak Coherence

In the existing research on course system construction, the coherence among the courses is weak, and there is an insufficient basis for establishing semester courses. The relationship between prerequisites and follow-up courses needs to be clarified. The connection between basic public and professional courses is too inflexible, and it is difficult to establish a connection between basic professional courses, professional core courses, and major-oriented courses. Most of the courses only copy the requirements of the National Standard on Teaching Quality of Undergraduate Majors in Regular Higher Education Institutions. The actual situation of the school and the actual development of regional industry and industry technology are not considered. The course setting is inflexible, and the mutual coherence is very weak. Some schools even arbitrarily adjust the start of the semester and the order of the courses practically, so integrity and coherence cannot be guaranteed at all, and the significance of the course system construction is also weakened.

2-4-5- Weak Symbiosis

Based on the existing studies on each course system construction, the symbiosis among courses is weak. There is a lack of a basic construction platform for each specific course, and the course setting does not break through the disciplinary barrier. The teachers of the courses of the same major or those of similar majors may lack the necessary communication, so they cannot teach the courses in the same major in a combined way. This not only means that there is a suboptimal allocation of resources but also that the growth of teachers in the course group is limited. As a result, each course is independent, and the professional course system lacks symbiosis, affecting the construction and development of majors and reducing the quality of talent training.

Based on the problems in the above research and practice, the present paper develops the group-chain development model of IT majors based on the vertical and horizontal integration of discipline-industry by analyzing the advantages and disadvantages of specialty groups and specialty chains and combining the practical situation of application-oriented undergraduate colleges. On the other hand, the 1+2+X course module system is constructed by revising the training plan of IT professionals, integrating, and optimizing courses, effectively realizing the systematic cultivation and improvement of the comprehensive professional quality and ability of IT industry talents, and improving the training level of application-oriented talents and the ability to serve local areas.

3- Theoretical Basis

In recent years, to cope with major changes in the industrial structure, China has actively explored new ideas and modes of professional cluster construction in local higher education institutions to meet the requirements for the development of regional industrial clusters. Since 2014, the Ministry of Education and other ministries have successively issued the Modern Vocational Construction System Plan (2014-2020), the Guiding Opinions on Guiding Some Local Universities to Transform to Application-oriented Universities, the General Office of the State Council issued Several Opinions on Deepening Industry-Education Integration (GBF [2017] No. 95) and other documents to effectively guide and promote the construction of high-level application-oriented talent groups, effectively promote the connection between the talent group setting and industrial demand, the industrial chain, talent chain, and the innovation chain, eliminate the drawbacks of the traditional teaching of schools, and facilitate school-enterprise integration. The spirit of the documents above shows that integration among education, enterprises, industry, and daily life will be the eternal theme of modern education. This research adheres to Dewey's three pragmatic education concepts, which state that "education is life, education is growth, and education is experiencing a transformation," which effectively constructs a course system that promotes the mutual promotion of talent training and industrial development.

"Education is life." A school is also a form of social life, and the school also represents society. Only by taking the actual development of social industries as the ultimate objective of talent training and course construction can we effectively build a course with a clear sense of timeliness and pertinence. "Education is growth." Education aims to promote students' continuous growth. Only by developing a coherent course system can students' four-year study at a university relate to their career development after employment. Students' progressive development and progress can be promoted in basic courses concerning discipline, major, and industrial skills and promote the joint development of students' disciplinary literacy and industrial skills. "Education is experiencing a transformation." Experience is the interaction between an organism and the environment and is the core concept in Dewey's pragmatic philosophy and pragmatic education system. Only by integrating the accumulated technology and knowledge in the industry and industry development into each course of undergraduate talent training and developing a course system including basic courses in discipline and industry experiences can we effectively ensure the scientific and practicability of talent training. Based on the guidance of relevant documents and adhering to the core concept of Dewey's pragmatism, this paper explores the relevant elements of talent training, discipline development, and industrial development. It actively constructs a modular course system that meets the demands of discipline development, industry, and the individual development of IT majors.

4- Construction Process of the 1+2+X Modular Course System for Information Technology Majors

It is crucial to sort out the course system of IT majors and construct the 1+2+X course module system. Through the comparative analysis of the talent training objectives and course systems in computer science and technology, software engineering majors in the Liuzhou Institute of Technology, computer science, and technology majors in the College of Computer Science, Guangxi University of Science and Technology, software engineering majors in the Tus College of Digit, software engineering majors in the HTC VIVEDU School of Technology, and management information systems majors in the College of Economics and Management, the 1+2+X course module system with the characteristics of "1 basic course module in the discipline, 2 basic course modules in the major, X major-oriented course modules" is established. It is important to perform learning and teaching reform from the aspects of course setting, practical links, interdisciplinary practical training, and school-enterprise cooperation, explore ways to realize "innovative applications" based on a combination of "knowledge, ability, and quality" and cultivate innovative IT talent to adapt to social requirements. The methodology is shown in Figure 1.

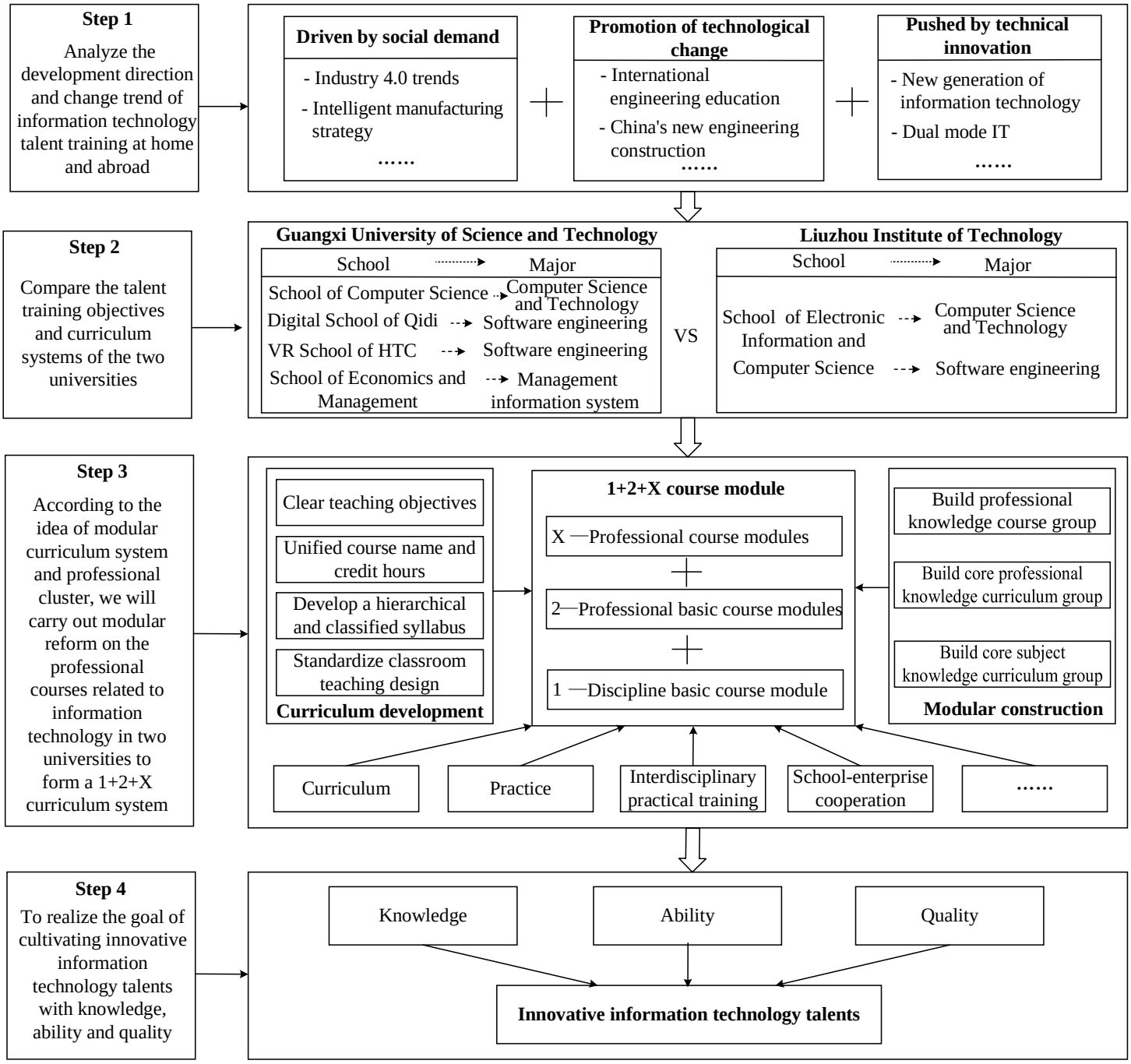

Figure 1. Research flow chart

4-1-1+2+X Course Module Construction Ideas

4-1-1- Discipline-driven Construction Mode of the Information Technology Talent Training System

The IT talent in regular higher education institutions will ultimately adapt to market demand. Therefore, it is necessary to transform market demands into the objectives and orientation of talent training in higher education institutions, determine the talent training directions, and optimize the talent training system to make it industry-oriented and market-oriented, as shown in Figure 2.

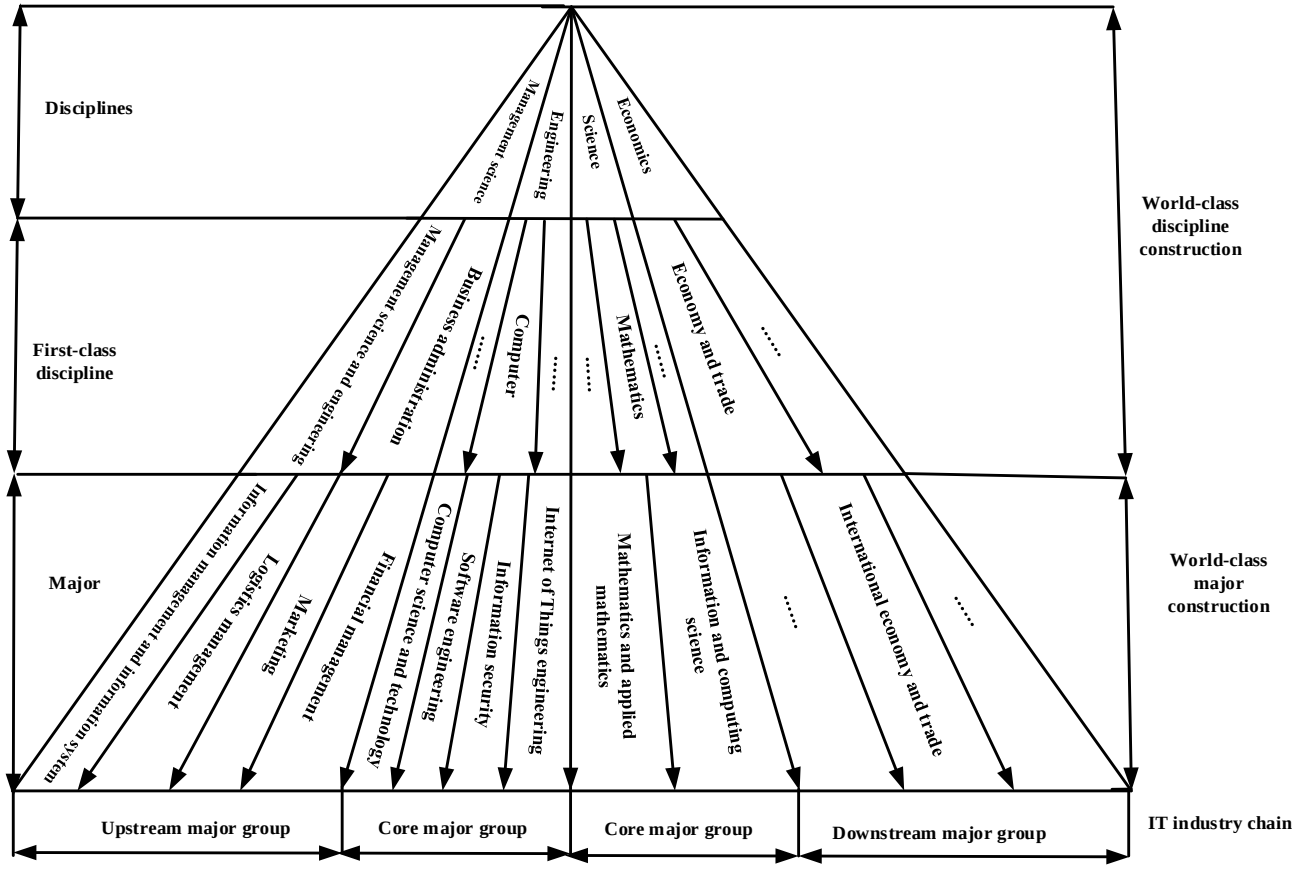

Figure 2. Vertically Integrated Training System of Information Technology Talent

The training objective for innovative, application-oriented, and skilled talent is to train students to meet the needs of society and industry, and it requires them to have solid theoretical knowledge with sufficient practical experience and excellent comprehensive quality, all of which are higher requirements and challenges for the traditional talent training mode. Through research on school-enterprise education cooperation practice between schools and Tus Group and HTC VIVEDU Education Group, the school-enterprise cooperative education mode can be realized, highlighting the advantages of schools and enterprises rationally allocating the resources of both sides to promote the training of IT talent better.

4-1-2- Industry-driven Construction Mode of the Hierarchical Information Technology Talent Training System

The dual-mode IT helps enterprises gradually transition from traditional to new IT. It involves higher talent requirements for the training system and IT mechanism in regular higher education institutions. Graduates need to have solid theoretical knowledge with professional skills and practical experience. Practically, higher education institutions should adopt the mode of "school-enterprise cooperation and collaborative education," comprehensively consider students' learning interests, professional levels, and job-seeking intentions, and establish a reasonable and flexible teaching plan, as shown in Figure 3.

It is important to develop the Internet+ system for innovative students, focusing on the modular course system in emerging application fields, for example, big data analysis, mobile application development, cloud platforms, social networks, and virtual reality. Developing the industry 4.0 system for application-oriented students is important, focusing on the modular course system in applications, including software engineering, system implementation, operation, and maintenance management.

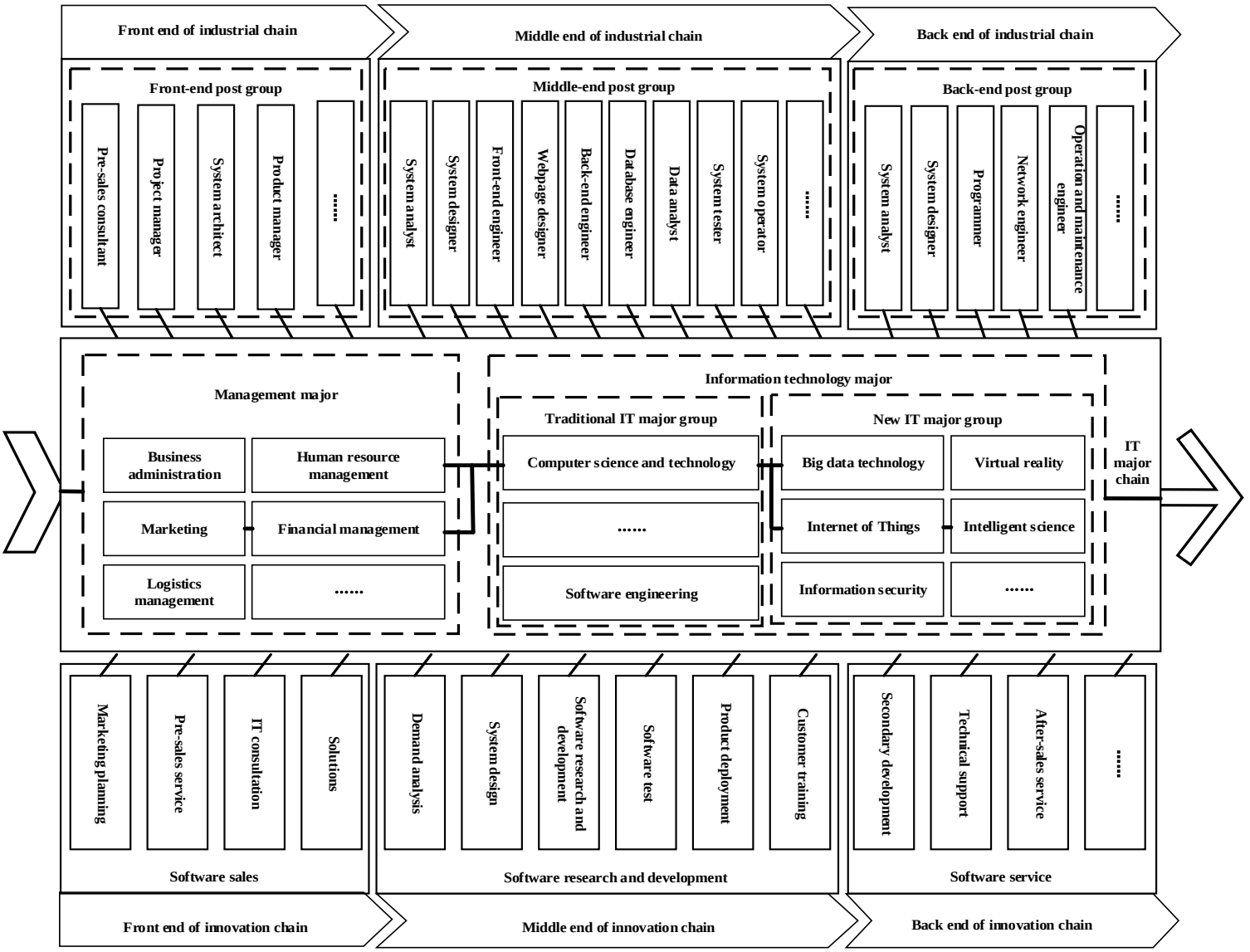

Figure 3. Horizontally Integrated Training System of Information Technology Talent

Promoting the mode of "school-enterprise cooperation and collaborative education" and forming a practical application of talent training in emerging engineering education is crucial. Through data access and field surveys, researchers studied the current cooperation mode of the Liuzhou Institute of Technology, summarized and analyzed the current cooperation mode, and clarified the thoughts and measures of cooperation in regular institutions in emerging engineering education. For IT majors, the software engineering major at Tus College of Digit, which was co-founded by Guangxi University of Science and Technology and Tus Group, is subdivided into intelligence science, data science, cyberspace security, mobile application development, etc. The software engineering major of the HTC VIVEDU School of Technology, co-founded by the Guangxi University of Science and HTC Group, is oriented towards virtual reality application and system engineering. The information system and information management majors in the College of Economics and Management have transformed from the training objective of systematic analysis, design, and realization of information systems to IT project management, big data application, and management talent. It is important to research how to explore a new talent training mode of "school-enterprise cooperation and collaborative education" according to the training objectives and orientation of different professional talents to develop a new training measure for IT talents under different cooperation modes.

4-2-1+2+X Course Module Construction Ideas

The paper analyzes the social application fields of the third generation of IT, including big data analysis, mobile application development, social networks, and virtual reality, and studies the theoretical and practical course systems to form a talent training plan for IT majors, especially the 1+2+X modular course system, which establishes a four-year talent training plan in universities and can take course universality into account, for example, by establishing one basic course module in the discipline (a modular course system of different disciplines formed by basic courses, including C

programming language and database). It can be applied to the teaching requirements of computer science and technology, software engineering, information systems, information management, etc. The establishment of two basic course modules in the major (a modular course system of different majors formed by basic courses, including object-oriented design, Python program design, and web design, which is suitable for different majors' hierarchical training and teaching requirements). The establishment of X major-oriented course modules (a course system that reflects the orientation characteristics of different majors, including introducing big data applications and management, modern IT project management, and other courses into the information system and information management majors in the College of Economics and Management. Tus College of Digit offers courses in intelligent science, network security, mobile development, and big data technology. HTC VIVEDU School of Technology provides relevant professional courses, including virtual reality and system engineering). The difficulty of the formation of the program lies in how to interconnect the talent training links of related majors through collaboration between colleges and departments, integrate the resources of schools in the basic "1+2" stage, highlight the advantages of enterprises in the "X" stage of professional courses, and establish different training characteristics among IT majors, as shown in Figure 4.

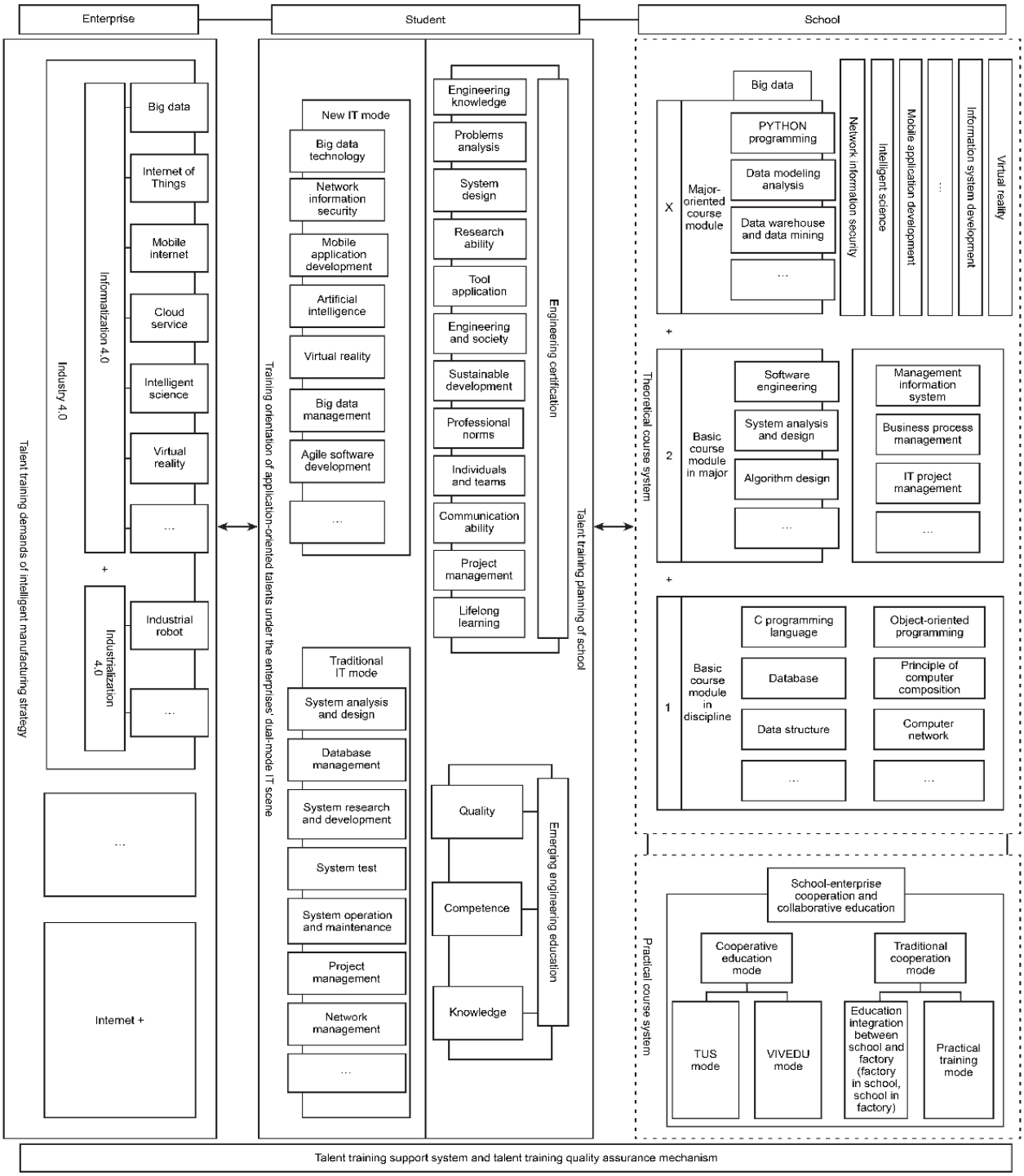

Figure 4. 1+2+X Modular Course System Diagram of Information Technology Majors

5- Construction Principle of the 1+2+X Modular Course System for Information Technology Majors

5-1- Clear Orientation and Starting Point

Application-oriented higher education should be "market-oriented." The orientation for the construction and development of application-oriented higher education institutions should be ascertained. In the construction and development process, the differences between application-oriented higher education institutions and discipline-oriented ones should be clarified to find a clear path forward and open up new prospects for construction and development. Meanwhile, it should be clear that the construction and development of this course system differ from those of higher vocational colleges. The discipline and specialty of application-oriented higher education institutions should be used to cultivate application-oriented undergraduate talents by taking "world-class disciplines" and "world-class majors" as the starting point.

5-2- Adapting to the Times and Aiming at Innovative Points

The mode of “school-enterprise cooperation and collaborative education” should be adopted in the construction of application-oriented higher education institutions to introduce new technologies and requirements to conform to the trends of the times, establish new courses, update the professional course layout and course content, and highlight the enterprise advantages and technical advantages of talent training, provide reasonable solutions for the limitations of the original training modes, combine with the regional industrial advantages and aim at the innovation and breakthrough points based on ensuring the effective teaching of discipline knowledge and professional knowledge to create innovative talent training orientation and mode and promote the effective connection between school education and industry development.

5-3- Professional Chain-based and Industrial Chain-oriented Systems

The talent training of IT majors should be based on the major itself to realize the scientificity and professionalism of talent training starting from the major topics and knowledge system of the major and effectively ensure that students master sufficient professional knowledge and skills. At the same time, an industry-oriented talent training system and courses that can cover the front end, middle end, and back end of the industrial chain should be set up to ensure that students can choose and learn courses that make them competent at all ends of the industrial chain based on their majors and personal interests and that have solid professional quality.

5-4- Discipline-based and Market-Oriented

The starting point of the course system construction for IT majors should be based on the scientific rationality of the discipline, and the course teaching outline should be planned according to the discipline and major. At the same time, the course system should be market-oriented and use market demands as the starting point of the course setting, teaching, and development to ensure that the ultimate objective of each course adapts to the industrial and innovation chain terminal.

6- Characteristics of the 1+2+X Modular Course System for Information Technology Majors

Based on big data analysis, the talent training scheme and reconstruction of the knowledge and talent quality framework should be optimized and integrated, starting with market demand. The mainstream of core competence training should be followed, and the cultivation of skills and qualities should be incorporated. The content of the teaching and course systems should be studied in depth; the course systems of different disciplines should be followed; and different majors and related majors with different orientations should be considered through education concept innovation. Then the 1+2+X course system with the characteristics of "1 basic course module in the discipline, 2 basic course modules in the major, and X major-oriented course modules" should be established.

6-1- Clear Guidance and Strong Indications

The modular course system is "market-oriented." It takes "world-class disciplines" and "world-class majors" as the starting point to orient the skill requirements for students’ employment from the perspective of enterprises to determine the courses offered by schools and selected for majors. The whole course system is configured and constructed around the talent training objective of being "innovative, application-oriented, and skilled." Courses from the basic course in the discipline and that in the major to the major-oriented courses corresponding to each professional chain link have obvious purposes and strong guidance, leading the whole talent training content from disciplines to industrial terminals and directly serving the employment requirements of students and the post requirements of enterprises, which meet the talent training requirements and the training requirements of professional ability.

6-2- Keeping up with the Times and the Latest Technology

Based on consolidating the basic knowledge of disciplines and basic professional skills, many corresponding major-oriented modules should be built according to the market and industry demands of different majors. Cutting-edge

technology courses, including big data technology, network security, mobile development, and virtual reality, should be introduced through school-enterprise cooperation, including the technologies and capabilities needed in each link of the entire industrial chain. The major course layout and course content should be updated on time to include all aspects of cutting-edge development into the course and the whole teaching process, highlighting the advantages of enterprises and technology, achieving a close connection between talent training and technology development, and avoiding the serious disconnection between school education and industry development.

6-3- Strong Pertinence and Orienting to all Links of the Industrial Chain

There is strong pertinence for the technical requirements of each link in the industrial chain, among which the major-oriented module setting and course arrangement bring differentiation and characteristics to talent training. According to different links in the industrial chain, courses are set up in different orientations so that the knowledge and skills mastered by students can match the specific posts after graduation. At the same time, many courses are offered and taught in cooperation with enterprises, so the "X" module highlights practicality and pertinence. Enterprises, colleges, and universities can offer courses and train students in a focused and planned way according to industry technology and enterprise talent requirements, realizing direct matching between the course setting and teaching and the market.

6-4- Closely Linked System and Consistent Courses

According to the 4-year academic structure of training in a major, the specialized group structure of discipline–major, and the technical requirements of industrial chain–innovation chain, and according to different job requirements and industry requirements, the courses of the basic module in the discipline, the basic module in the major and the major-oriented module should be scientifically and reasonably configured to combine universality with specialty and the course order and hierarchical structure should be arranged in an orderly manner to realize orderly and standardized major training, which is more in line with the requirements and order of knowledge teaching and mastery and emphasizes the relationship between prerequisite courses and follow-up courses and the evolution of specialty technology to form a rigorous curriculum system.

6-5- Teaching Courses in a Combined Way to Achieve Coordinated Development

The courses covered by this system belong to the same or similar disciplines, serve the same industrial chain and innovation chain, and connect all links between disciplines and industries. The teaching contents of each course supplement each other, the knowledge system can be integrated, and the achievements of course construction can achieve resource sharing and complementarity. All the courses in the system are set up and taught around the ultimate industrial demand. Teachers can effectively communicate the ultimate objective of talent training. This is helpful for the mutual promotion and harmonious development of all courses in the system.

7- Discussion

The main findings of this study are the successful presentation and testing of the 1+2+X modular curriculum system in two Chinese universities by adopting the concept of group chain. The research paper successfully proposed a process and characteristics for the training plan of IT majors by integrating and optimizing the curriculum based on the concept of the 1+2+X curriculum module system.

The 1+2+X modular curriculum system proposed in this paper is comparatively different from the previous research and practice that only talks about the importance of universities and industry integration in recent times to meet the technology-based talent in China [17, 18]. The present research, on the other hand, constructs a new idea of the 1+2+X modular curriculum system to get professional development and student training simultaneously. The proposed curriculum system is no longer limited to IT or engineering backgrounds. However, it can be blended for any discipline, and their respective industry demands to produce the required talent for the field [12].

From an implication and strength point of view, this study has solved the problem that talent cultivation does not fit well with enterprises and how to bring reform to the Chinese universities' curriculum [2]. It also addressed the imbalance between supply and demand in the IT employment market, as mentioned in the "Made in China 2025" strategy [1]. So, the Chinese government and higher education institutes need to work on the concept of a modular course system, as shown through this research, to cultivate the right fit and balance talent supply from the institutes as per the demand of the market trend.

8- Conclusion

The paper proposed the 1+2+X modular curriculum system based on group-chain development for IT majors. The comparative analysis from the study not only supports the concept that can bring professional development and student training at the same time to produce more technology-based talents but also fills the gap in the literature from the aspect that universities in China and enterprises together can produce technology-based talent, but the evidence was missing. It can be concluded that the curriculum system's construction should not be limited to subject specialization only. However, it must be designed by blending the subject's knowledge with industry trends and demands.

The study has a limitation based on performing the comparative analysis on technology-driven universities still in the initial exploration stage because they were built and started late. Also, these universities have a low degree of integration with local industries. Given the above two limitations, future researchers can plan to test the idea at research-oriented universities and higher vocational colleges.

In conclusion, the researchers have solved two main practical problems: the integration problem between universities and enterprises for talent cultivation and changing the traditional curriculum to professional training and subject-based knowledge. The paper also contributes new theoretical information about the process and characteristics of the 1+2+X modular curriculum system to the literature.

9- Declarations

9-1- Author Contributions

Conceptualization, M.L., and H.B.; methodology, H.B.; software, M.L.; validation, H.B., M.L., and Y.M.; formal analysis, H.B.; investigation, M.L.; resources, G.L.; data curation, T.W.; writing—original draft preparation, T.W.; writing—review and editing, T.W.; visualization, H.B.; supervision, H.B.; project administration, T.W.; funding acquisition, T.W. All authors have read and agreed to the published version of the manuscript.

9-2- Data Availability Statement

Data sharing is not applicable to this article.

9-3- Funding

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9-4- Institutional Review Board Statement

Not applicable.

9-5- Informed Consent Statement

Not applicable.

9-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

10- References

[1] Wei, M. (2016). Systematically Promoting Intelligent Manufacturing and Speeding Up the Construction of a New Manufacturing System - Speech of Miao Wei, the Minister of Industry and Information Technology, at the Experience Exchange of National Intelligent Manufacturing Pilot Demonstration. Equipment Manufacturing, 8(08), 30-34.

[2] Ming, L., Zhiping, L., Chenfei, W., & Changchun, J. (2016). “Dual-mode IT” Theory and Practice: Transformation of IT Strategy and Service Management in Automobile Manufacturing Industry. Manufacturing Automation, 39(09), 98-101.

[3] Action of Tianjin University. (2017). “Emerging Engineering Education” Construction Action Route. Research in Higher Education of Engineering, 2(02), 24-25.

[4] Frymier, J. R. (1973). Developing a Curriculum system. Theory Into Practice, 12(3), 201–204. doi:10.1080/00405847309542452.

[5] Yang, L. H., Liu, B., & Liu, J. (2021). Research and Development Talents Training in China Universities—Based on the Consideration of Education Management Cost Planning. Sustainability, 13(17), 9583. doi:10.3390/su13179583.

[6] Chen, G., Li, X., Zhang, X., & Reniers, G. (2021). Developing a talent training model related to chemical process safety based on interdisciplinary education in China. Education for Chemical Engineers, 34, 115-126. doi:10.1016/j.ece.2020.11.012.

[7] Yongqiang, Y., & Lijun, Y. (2013). Construction of modular curriculum system for mechanical specialty based on OBE concept. New West China: Midday Theory, 12 (12): 22-24.

[8] Lin, G., & Tang, Y. (2015). Application of CDIO in practice and training of an engineering automation specialty. World Transactions on Engineering and Technology Education, 13(3), 407-411.

[9] Felder, R. M., & Hadgraft, R. G. (2013). Educational practice and educational research in engineering: Partners, antagonists, or ships passing in the night? Journal of Engineering Education, 102(3), 339–345. doi:10.1002/jee.20015.

[10] Bin, X. (2019). Research on the construction of undergraduate curriculum system for innovative engineering talents. Tianjin University, (June 2019), 43-46, Tianjin, China.

[11] Burke, L. E. C. A., Chong, A., Evans, G. J., & Romkey, L. (2020). Cultivating Disciplinary Expectations for Engineering Education Research in Canada. Canadian Journal of Science, Mathematics and Technology Education, 20(1), 87–97. doi:10.1007/s42330-020-00078-7.

[12] Brennan, R. (2018). A Systematic Review of Canadian Engineering Education Research 2004-2017. Proceedings of the Canadian Engineering Education Association (CEEA), CEEA-ACEG1 8, Paper 137 1-5. doi:10.24908/pceea.v0i0.13079.

[13] Suning, T. (2013) Russian engineering education and engineering elite education model. China Metallurgical Education, (June 2013), 79-81. doi:10.16312/j.cnki.cn11-3775/g4.2013.06.027.

[14] Wenjie, Y., Jun, L., Chengji, D., & Hongxi, Z. (2014). Higher engineering education in Brazil and its enlightenment. Education Observation (last ten-day), 3(02), 43-47. doi:10.16070/j.cnki.cn45-1388/g4s.2014.02.022.

[15] Burke, L. E. C. A., Chong, A., Evans, G. J., & Romkey, L. (2020). Cultivating disciplinary expectations for engineering education research in Canada. Canadian Journal of Science, Mathematics and Technology Education, 20, 87-97. doi:10.1007/s42330-020-00078-7.

[16] Hanbing, K. (2011). Engineering Discipline: framework, ontology and attribute. Hangzhou: Zhejiang University Press, (July 2011), 202-205.

[17] Hai, D., Chunyan, X., Dan, Y., Yongchang, Z., Pengfei, S., & Shoufan, R. (2022). Course system construction of material forming and control engineering based on engineering education certification. Economist, (September 2022), 213-214.

[18] Zhenfeng, Z., Zehua, L., Dong, X., & Lifeng, Z. (2022). Exploration of building electrical and intelligent professional curriculum system construction based on engineering education certification. Research and Practice of Innovation and Entrepreneurship Theory, 5(17), 1-3.

[19] Haihua. Z. (2023). Research and practice on the construction of OBE-based "general knowledge" plus "extensive professional" curriculum system. Science and Technology Wind, 3(8), 8-10, Zhangjiajie College of Jishou University, Zhangjiajie, China.

[20] Jian, L. (2017). China's new engineering construction facing the future. Educational research of Tsinghua University, 38(02), 26-35. doi:10.14138/j.1001-4519.2017.02.002610.

[21] Zhang, D., Rong, C., Goh, H. H., Liu, H., Li, X., Zhu, H., & Wu, T. (2023). Reform of Electrical Engineering Undergraduate Teaching and the Curriculum System in the Context of the Energy Internet. Sustainability, 15(6), 5280. doi:10.3390/su15065280.

[22] Maoyuan, P., & Qunying, Z. (2009). On the application oriented undergraduate course construction from the perspective of university classification. China University Teaching, 3, 4-7.

[23] Salama, A. M. (2005). Skill-based/knowledge-based architectural pedagogies: An argument for creating humane environments. In 7th International Conference on Humane Habitat-ICHH. Rizvi College of Architecture, January 29-31, Mumbai, India.

[24] Guoqing, C., & Yongqin, Z. (2017). Thoughts on the construction of Applied Undergraduate Curriculum System - curriculum system reform guided by work process. Journal of Qiqihar Institute of Engineering, 18(4), 1-3.

[25] Chunrong, Z. (2010). Reconstruction of applied undergraduate curriculum system guided by professional ability - taking marketing specialty as an example. Vocational and Technical Education, 35(8), 3-4.

[26] Fei, C. (2014). Research on curriculum adjustment and reform of applied undergraduate education. East China Normal University, (June 2014), 25-28.

[27] Mingyi, W. (2014). Reflections on the transformation and development of local undergraduate colleges. China higher education, 29 (8), 2-4.

[28] Yu, L. (2021). Research and Enlightenment of American Community College Curriculum System. Teacher Education and Curriculum Studies, 6(1), 33. doi:10.11648/j.tecs.20210601.17.

[29] Jenkins, D., & Cho, S.-W. (2013). Get With the Program … and Finish It: Building Guided Pathways to Accelerate Student Completion. New Directions for Community Colleges, 2013(164), 27–35. doi:10.1002/cc.20078.

[30] Scott-Clayton, J. (2011). The Shapeless River: Does a Lack of Structure Inhibit Students' Progress at Community Colleges? CCRC Working Paper No. 25. Assessment of Evidence Series. Community College Research Center, Columbia University, New York, United States.

[31] Wen, L., Wen, H., Lishao, H. (2018). Construction and Practice of Course System for Training Diversified Abilities of Application-oriented Talents - Taking Computer Science and Technology Major as an Example. Research and Exploration in Laboratory, 26(07), 48-52. doi:10.3969/j.issn.1006-7167.2018.07.057.

[32] Zhang, W., & Li, J. (2021). Research on the Teaching Reform of Electronic Information Specialty based on the Concept of CDIO Engineering Education. Journal of Physics: Conference Series, 1744(4), 22–36. doi:10.1088/1742-6596/1744/4/042236.

[33] Jingfeng, S., Chuangtao, M., & Ruichao, W. (2019). Construction of Course System in Information Management Major Based on the Integration of Ability, Post and Course. China Management Informatization, 13(7), 53–55.

[34] Ya, X., Jingwen, W., & Zhihang, T. (2019). Construction and research of software engineering course group for software engineering major under the background of emerging engineering education. Journal of Hunan Institute of Engineering, 19(04), 78–82.

[35] Lingru, T., Long, H., Sufujiang, Y., Duli, A., Jiangru, P., Geng, X., & Jiapeng, Y. (2023). Construction and practice of mechanical and electronic engineering curriculum system in the context of intelligent manufacturing. Southern Agricultural Machinery, 54(03), 195–198.

[36] Yinzhang, G., & Jianchao, Z. (2013). Construction and practice of talent group training mode for manufacturing informatization major. Computer Education, 19(04), 32–35.

[37] Jiansheng, W., Xiaoping, T., & Yongsheng, X. (2019). Analysis for construction of computer major group in application-oriented undergraduate colleges under the mode of integration of industry and education and collaborative education. Journal of Guangxi Science & Technology Normal University, 5(5), 19-23.

[38] Li, H., Yu, X., Wang, Y., & Yu, T. (2018). Research and Practice on Construction of a New Generation of Information Technology Specialty Based on the Demand of Intelligent Manufacturing Industry. DEStech Transactions on Computer Science and Engineering, iceiti. doi:10.12783/dtcse/iceiti2017/18909.

[39] Jian, C., Wenzhong, L., Pingsong, Z., Xiaoyang, C., Qimeng, L., & Rongxin, W. (2021). Construction of characteristic course system of geological engineering major in mining Universities under the background of engineering education certification - by taking Anhui University of Science and Technology as an example. Chinese Geological Education, 30(2), 43–48.

[40] Yu, J. (2020). Thoughts on the course system construction of agricultural engineering major under the background of emerging engineering education. Huazhong Agricultural University, (June 2020), 43-46. doi:10.27158/d.cnki.ghznu.2020.000339.

[41] Hui, C. (2020). Discussion on construction of "Internet +" modular course of electrical and electronic majors based on the "supply-side reform". Electronic Test, 65(18), 113–114. doi:10.16520/j.cnki.1000-8519.2020.18.047.