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Research on the Evolution of disciplinary competences of Physics for Secondary School in China's Centennial Curriculum: Text Analysis Based on Curriculum Standards

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A R T I C L E I N F O

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A B S T R A C T

This paper studies the target texts of 31 copies of physics curriculum standards for secondary school. The China's centennial physics curriculum standards can be divided into four stages. We first analyses the characteristics of the curriculum development with high-frequency words, and then carry out classification and a comparative study on historical development of the requirements for disciplinary competences from the following five dimensions: basic ability, comprehensive ability, problem-solving ability, epistemology, creative thinking. The study finds that the disciplinary competences of physics in China's centennial physics curriculum standards has been changing its focus--in terms of type, it has changed from the cultivation of basic knowledge-oriented ability to the coordinated development of five abilities; in terms of form, it has changed from separation to integration; in terms of expression, it has changed from being simple and obscure to being concrete and accurate; in terms of value orientation, each stage possesses its own characteristics.

1. Introduction

The curriculum standards are the curriculum program promulgated by the country and work as the guiding document for the implementation of curricula. In China, the curriculum objectives are set with the education expectation of Lide-Shuren (立德树人, fostering integrity and promoting rounded development of people) as well as their disciplinary competences. From The figureer of the Imperial in 1902, compiled under the lead of Zhang Baixi, minister of education in the Qing Dynasty, to Ordinary High School Physics Curriculum Standard (2017 edition), issued in January 2018, the China's physics curriculum standards for secondary school had been developing for more than 100 years. The first outline of teaching with explicit physics contents in China is the Outline of Nature Curriculum for junior high school, issued in 1923, since when the cultivation of students' disciplinary competences of physics has sat at the core of the goal of physics education. Disciplinary competences is more applied to evaluate students' disciplinary achievements in the field of international science education. Disciplinary competences refers to a sfigure psychological regulatory mechanism necessary for students to smoothly participate in the cognition activity and problem -solving activity of corresponding subjects, including the directional regulatory mechanism and executive regulatory mechanism. It involves systematic and structured knowledge and skills, as well as the schemes of experience in core activities of a certain subject（Wang, 2016）. The National Mid- and Long-term Educational Reform and Development Planning Outline (2010-2020) clearly states that: "we should attach great importance to competences, to optimize knowledge structure, to enrich the ability in social practice, to strengthen the cultivation of disciplinary competences, and to focus on improving students' learning ability, practical ability and innovation ability" (Central Committee of the Communist Party of China & The State Council of P. R. China, 2010). Lin Chongde (Lin, 1997), head of China's new round of the development of curriculum standards based on core literacy in 2018, gives the definition of disciplinary competences from the perspective of psychology that "disciplinary competences is a kind of personality traits which enable one to successfully solve the problem or complete the task of a subject". Disciplinary competences has the following four characteristics: (1)the special ability of a subject is the most direct embodiment of this disciplinary competences; (2)all kinds of subject abilities are based on the generalizing ability; (3)the structure of a disciplinary competences should consist of thinking quality; there exist individual differences among students' disciplinary competences. The research on the evolutionary trend of requirements for disciplinary competences within the context of the centennial physics curriculum standards for secondary school contributes to reflecting the requirements of China's physics curriculum for students' necessary disciplinary competences at different developmental stages as well as the changes of national requirements for scientific and technological personnel training in different periods and under different social backgrounds.The main didactic attributes of displaying using an

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interactive whiteboard.

2. Literature Review

For research on the standards for evaluating disciplinary competences, the American Standards for Scientific Capacity Performance, issued by the United States in 1998, divides students' scientific competences into eight aspects and five levels. Here are the eight aspects:concept of material science, concept of life science, concept of earth and space science, connection and application of science, scientific thinking, scientific tools and techniques, communication of science, and scientific investigation and study; the 5 levels are H--well up to standard, S--up to standard, N--close to standard, B--below the standard, L--no achievement (National Center on Education and the Economy and the University of Pittsburgh,1998). In 2008, the Quality Assurance Agency of Higher Education revised the benchmark of disciplinary competences of physics for an honors degree, dividing the competences into professional skills and general skills. Based on this frame, the performance of undergraduates' disciplinary competences of physics was divided into two levels: "threshold level" and "typical level"(Quality Assurance Agency of Higher Education,2008). International large-scale assessment programs, such as PISA, TIMSS and NAEP, focus on the assessment of students' disciplinary competences, aiming to improve the quality of education. The science subject assessment of the Program for International Student Assessment (PISA) of the OECD takes scientific literacy as the benchmark and focuses on the application of comprehensive ability. Meanwhile, it monitors cooperative problem-solving ability (OECD, 2016), and The assessment of creative thinking was added to PISA in 2018. The scientific assessment of PISA emphasizes the ability to creatively apply basic knowledge in real life, centering on four aspects of scientific literacy, namely scientific knowledge, scientific attitude, scientific competence and context. The science part of South Korea's National Assessment of Educational Achievement(NAEA) was designed to evaluate science competence of students in grades 7-9. The dimension of this assessment concerns contents and cognition, and the cognition part involves knowledge (memorizing, understanding, and application) and exploration (problem identification and hypotheses development, design and implementation of exploration, analysis and interpretation of data, evaluation and conclusion) (Kim, Lee &Kim, 2016). Based on the national and state curriculum standards, along with the experience of PISA and TIMSS, the assessment framework for the National Assessment of Educational Progress(NAEP) pays attention to scientific practice. Its involves the identification of science principles, the application of scientific inquiry, principles and design, and each dimension gets it's sub-dimension. The application of scientific design serves as an example. It is subdivided into (1) propose or discuss solutions to problems, and set the standards and scientific qualification; (2) identify scientific problems in design and choose solutions; (3) predict the effect of technically designed decisions with scientific principles or data (NAGB, 2014).Wang Lei (Wang, 2016), a representative scholar of science education research in China, constructed a disciplinary competences model from multiple dimensions such as the foundation of knowledge and experience, activity performance, the cognition mode and development levels of subjects[7]. Duan Jinmei and Wu Jianshi (Duan & Wu, 1988) proposed that the physics teaching in secondary school should focus on the cultivation of experimental observation ability, thinking ability, problem analysis ability and problem-solving ability, self-learning ability and creative thinking ability. Su Rui, Li Laizheng(Su & Li 1992) divided the disciplinary competences of physics into pattern recognition ability, experimental analysis ability, thinking phenomenon ability, screening and storage ability, knowledge transferring ability and mathematical reasoning ability, etc.. With reference to the characteristics of physics, Guo Yuying and others (Guo Zhang &Yao, 2016), based on the model of "the research on primary and secondary school students' disciplinary competence performance", which studies students' disciplinary competences and performance such as learning and understanding, practice and application, transfer and innovation, put forward the framework of disciplinary competence performance of physics which has three dimensions (learning and understanding, practice and application, transfer and innovation) and nine first-level indicators.

For research on the evaluation of science curriculum standards, the international studies on physics curriculum standards give priority to science curriculum standards, including the study on the language used in curriculum standards. With reference to specific cases, Wallace and others, after studying the language from national scientific standards of the United States over the past 15 years, analyzed the influence of the language in curriculum standards on science subject teaching from several aspects such as education policy, science education, curriculum theory and critical inquiry and their own experience. Referring to the characteristics of the New Zealand science curriculum, their study also showed the language has potential to improve science teaching, which provided reference for language understanding curriculum standards(Wallace，2012). Taking science-teacher-to-be program as standard, the study focuses on the influence the curriculum standards has on pre-service science teachers' attitude to science teaching with reference to science education background. The results show that such standard-based program contributes nothing to significantly improving pre-service science teachers' teaching attitude. Actually, a science teacher's teaching attitude gradually develops in the long-term process of teacher education（Buaraphan，2011）. International research on science curriculum standards includes cognition and implementation, but there is little research on the disciplinary competences in curriculum standards. Therefore, we takes China's centennial physics curriculum standards for secondary school as the research text to analyze the revolutionary characteristics of its requirements for disciplinary competences of physics, so as to provide research evidence of historical text and scientific evidence of empirical analysis for the revision of China's physics curriculum standards and the reform of science education. This paper intends to explore the following three questions:

1. What are the classification standards for the interpretation of the disciplinary competences in China's physics curriculum standards for secondary school ?
2. What are the characteristics of the development of the disciplinary competences in China's physics curriculum standards for secondary school ?
3. What are the evolutionary rules of the disciplinary competences in China's centennial physics curriculum standards for secondary school?

3. Research Method

Based on pedagogy and characteristics of subjects, the international academic community's assessment of the disciplinary competences of science focuses on the diversification and contextualization of competence assessment. The assessment of disciplinary competences of physics is included in the unified assessment system of science subjects, and the hierarchical assessment indicators first divide the competences into different fields, the essence of which is to distinguish the static ability and dynamic ability of disciplinary competences, meanwhile pay attention to the a high level of thinking ability. The disciplinary competences assessment in China is based on psychology and integrates the characteristics of specific subjects. It focuses more on the learning ability at the micro level and the homogeneity of each dimension, while less attention is paid to the heterogeneity of ability. Curriculum standards generally include curriculum objectives, curriculum contents, curriculum implementation, and the evaluation and suggestion of curriculum. The target text of curriculum standards reflects a nation's overall plan and requirements for the course, the planner's value orientation towards the curriculum policy as well as the specific requirements of the course for the students' training objectives (Yang, Zhao, &Liu, 2018). Therefore, we analyse disciplinary competences with a focus on texts of this part. We also take into account the field of competences, the characteristics of hierarchical classification in international disciplinary assessment, and the homogeneity of China's disciplinary competences dimension. Based on the latest assessment framework of PISA(issued in 2018), Bloom's teaching objective classification system and Gagne's classification of learning outcomes, we study the target text of the physics centennial curriculum standards (part with the same effect is taken if there's no curriculum objectives), and divide the disciplinary competences of physics into the following five dimensions; basic ability, comprehensive ability, problem-solving ability (subdivided into practical application, cooperation and communication, scientific method, cognition and thinking), epistemology (subdivided into values, emotions and attitudes, personality, the nature of subjects) and creative thinking, and each one is provided with the operational definitions and cases for reference (table 1).

Table 1 Classification and operational definition of disciplinary competences of physics in secondary school curriculum

Classification		Specific description
Basic ability		Students' ability to recognize, memorize, and understand basic knowledge such as concepts, laws, and principles of physics, as well as a preliminary understanding of the relationship between physics and other subjects, nature, as well as society. The whole process involves only the input of knowledge and the students' understanding and memorization. It is the most basic competence of physics.
Comprehensive ability		Students' ability to express their knowledge through action or body language after mastering the basic ability. There's little cognition and thinking involved in this process, just a few spontaneous and simple abilities, such as observing ability and preliminary operational ability.
Problem solving	Practical application	Students apply the knowledge to address practical problems or explain related phenomena. It's mainly about the solution of ill-structured problems.
	Experimental operation	Students' preliminary skills in experimental operation, including using simple experimental instruments, measuring some basic physical quantities, having safety consciousness, knowing basic methods to record and process data, utilizing simple figures to describe experimental results, writing simple experimental reports, and accurately presenting, evaluating and reflecting inquiry process and results.
	Cooperation and communication	Students have the intention to cooperate and communicate with others. Students get problems solved through cooperation, communication, experience, participation, etc., or acquire abilities in cooperation, expression and some others in the problem-solving process.
	Scientific methods	Through learning, students master some scientific methods and can use them to address problems in learning progression. For instance, students learn to solve some physical problems with methods such as scientific inquiry, induction and analysis, or to acquire the ability to use scientific methods in the process of solving problems.
	Cognition and thinking	Students can use the knowledge they have learned to solve physical problems and apply this mindset to the solution of practical problems or have the consciousness to solve problems with this mindset. For example, apply science and technology to daily life and social practice.
Epistemology	values	Students transform their attitudes and develop their outlooks on world and life through the learning and practice of a certain subject, along with the emotional experience in this process. For example, the learning process helps to lay the foundation of a dialectical materialist worldview for students.
	Emotions and attitudes	Through learning, students grow more enthusiastic about physics, find knowledge that interests them, generate intention to study further, have confidence and determination to overcome difficulties, and have scientific attitudes and spirits to uphold the truth, to innovate, and to seek truth from facts.
	Personality	Through learning, students develop psychological characteristics like temperament, competences, habits and personality, and can continuously promote the development of their personality so as to grow into a well-rounded person.
	Nature of the subject	Through learning, students can think about matters concerning society, the country, and the world from the perspective of the subject, can explore the changes and effect the subject brings to nature and society, and can understand the meaning and value of a subject, as well as the nature of physics.
Creative thinking		Through learning, students can think independently, dare to question, and creatively explore and solve problems in learning and life.

In order to clarify the history and characteristics of the disciplinary competences of physics over the past about one-hundred years, this research refers to 31 copies of physics curriculum standards promulgated from 1923 to 2017 (Institute of Curriculum and Textbook Research, 2001; Ministry of Education, P. R.China, 2001; 2003; 2011; 2017), and divide the development of curriculum standards into four stages in chronological order: from the end of the Qing Dynasty to the time before the founding of the People's Republic of China (1902-1948), from the early period of the founding of the People's Republic of China to the beginning of reform and opening up (1949-1987), from the tenth year of reform and opening up to the end of the 20th century (1988-2000), from the new curriculum reform to the present (2001 to 2017). The first stage was the introduction and preliminary development of the physics curriculum. A total of 14 copies of physics curriculum documents for secondary school were issued (figure 2). The second stage was the recovery and development of the physics curriculum with a focus on the basic knowledge and experimental ability of physics and 6 curriculum documents were issued at this stage. It underwent the early days of the founding of the People's Republic of China when everything waited to be rebuilt and the 10-year cultural depression of the Cultural Revolution, and it also witnessed the "spring for education" brought by the reform and opening up (table3). The third stage was the support for the national economic construction based on the experimental ability and the application of physics. At this stage, six curriculum documents were promulgated, including three editions for junior high school, two editions for senior high school, and one comprehensive edition. China's education gradually recovered after the reform and opening up. Focusing on economic construction, it pays greater attention to the cultivation of students' ability to master science and technology (table 4). The fourth stage experienced a booming development, aiming to cultivate well-rounded people with a focus on scientific inquiry and core literacy. At the beginning of this century, China carried out the eighth curriculum reform of elementary education. As of 2018, a total of four curriculum documents were issued, including two editions for junior high school and two editions for senior high school. The physics curriculum standards based on core literacy for senior high school were issued in 2018 (table 5).

Table 2 Structure of China's different editions of physics curriculum standards for secondary school and the location of target text from early 19th century to the time before the founding of the People's Republic of China (1902-1948)

Year	Name	Overall structure	Location
1923	*Outline of the Natural Curriculum for Junior High School*	1. Objectives 2. Contents and Methods 3. Minimum standards for graduation	Objectives
	Outline of the Public Compulsory Introduction to Science for Senior High School	1. Lecture duration and credits 2. Objectives 3. Contents and Methods	Objectives
	Outline of Compulsory Physics Curriculum for Group 2 of Senior High School	1. Lecture duration and credits 2. Outline 3. Description	Description: Experimental requirements
1929	*Interim Curriculum Standards for Science in Junior High School (Mixed)*	1. Objectives 2. Main assignments 3. Time allocation 4. Outline of teaching materials 5. Key points of teaching 6. Minimum standards for graduation	Objectives
	Interim Curriculum Standards for Physics And Chemistry in Junior High School(Branched)	1. Objectives 2. Main assignments 3. Time allocation 4. Outline of teaching materials 5. Key points of teaching	Objectives
	Interim Curriculum Standards for General Physics in Senior High School	1. Objectives 2. Main assignments 3. Allocation of time and credits 4. Outline of teaching materials 5. Key points of teaching 6. Minimum standards for graduation	Objectives
1932	*Physics Curriculum Standards for Junior High School*	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Summary of implementation methods	Objectives
	Physics Curriculum Standards for Senior High School	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Summary of implementation methods	Objectives
1936	*Physics Curriculum Standards for Junior High School*	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Summary of implementation methods	Objectives
	Physics Curriculum Standards for Senior High School	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Summary of implementation methods	Objectives
1941	*Revision of Physics Curriculum Standards for Junior High School*	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Summary of implementation methods	Objectives
	Revision of Physics Curriculum Standards for Senior High School	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Summary of implementation methods	Objectives
	Draft Six-year Physics Curriculum Standards for Secondary School	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Summary of implementation methods	Objectives
1948	*Revision of Curriculum Standards for Physics And Chemistry in Junior High School*	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Implementation methods	Objectives
	Revision of Physics Curriculum Standards for Senior High School	1. Objectives 2. Time allocation 3. Outline of teaching materials 4. Implementation methods	Objectives

*Note: Curriculum documents issued in the same year are merged in the frequency change diagram. The Draft Six-year Physics Curriculum Standards for Junior High School is counted twice because there's no division of junior and senior high school. The final statistical results are 6 for junior high school and 6 for senior high school.

Table 3 Structure of China's different editions of physics curriculum standards for secondary school and the location of target text from the early period of the founding of the People's Republic of China to the beginning of reform and opening up (1949-1987)

Year	Name	Overall structure	Location
1952	*Draft Physics Curriculum Standards for Secondary School*	1. Overall description 2. Objectives of junior/senior high school 3. Textbook contents 4. Teaching hours 5. Implementation methods 6. Equipment standards	Objectives of junior/senior high school

	Outline of Physics Teaching for Secondary School(Draft)	1. Overall Description 2. Description of the outline for junior high school 3. Description of the outline for senior high school 4. Outline	Overall Description
1956	*Outline of Physics Teaching for Secondary Schools(Revised Draft)*	1. Overall Description 2. Description of the outline for junior high school 3. Description of the outline for senior high school 4. Outline	Overall Description
1963	*Outline of Full-time Physics Teaching for Secondary School(Draft)*	1. Teaching objectives and requirements 2. Teaching contents 3. Arrangement of teaching contents 4. Demonstration and students' experiments 5. Points to be given attention to in teaching 6. Teaching contents of all grades in junior high school 7. Teaching contents of all grades in senior high school	Teaching objectives and requirements
1978	*Outline of Physics Teaching for Secondary School(Trial Draft)*	1. The objective of physics teaching 2. Several basic principles of physics teaching 3. Arrangement of teaching contents 4. Problems to be given attention to in teaching 5. Teaching contents of all grades	Objectives of physics teaching
1986	*Outline of Full-time Physics Teaching for Secondary School*	1. Objectives of physics teaching 2. Requirements for physics teaching 3. Contents and principles of physics teaching 4. Points to be given attention to in teaching 5. Teaching contents of all grades	Objectives of physics teaching

Note: Curriculum documents issued in the same year are merged in the frequency change diagram. If there's no division of junior and senior high school in the outline, the competence will be counted twice. The final statistical results are 5 for junior high school and 5 for senior high school.

Table 4 Structure of China's different editions of physics curriculum standards for secondary school and the location of target text from the tenth year of reform and opening up to the end of the 20th century (1988-2000)

Year	Name	Overall structure	Location
1988	*Outline of Full-time Physics Teaching for junior high school*	1. Teaching objectives 2. Determination of teaching contents 3. Problems to be given attention to in teaching 4. Description of teaching requirements 5. Teaching contents and teaching requirements	Teaching objectives
1990	*Outline of Full-time Physics Teaching for secondary School*	1. Objectives of physics teaching 2. Requirements for physics teaching 3. Principles of physics teaching contents 4. Points to be given attention to in teaching 5. Teaching contents of all grades	Objective of physics teaching
1992	*Outline of Full-time Physics Teaching in junior high school for Nine-year Compulsory Education*	1. Teaching objectives 2. Determination of teaching contents 3. Problems to be given attention to in teaching 4. Description of teaching requirements 5. Teaching contents and teaching requirements 6. Arrangement of class duration	Teaching objectives
1996	*Outline of Full-time Physics Teaching for General Senior High School*	1. Teaching objectives 2. Class schedule 3. Determination of teaching contents 4. Problems to be given attention to in teaching 5. Teaching contents and requirements of compulsory physics curriculum 6. Teaching contents and requirements of compulsory and optional physics curriculum 7. Examination	Teaching objectives
2000	*Outline of Full-time Physics Teaching for Junior High School*	1. Teaching objectives 2. Determination of teaching contents 3. Problems to be given attention to in teaching 4. Description of teaching requirements, teaching contents and teaching requirements 5. Assessment and evaluation 6. Arrangement of class duration	Teaching objectives
2000	*Outline of Full-time Physics Teaching for General Senior High School*	1. Teaching objectives 2. Curriculum arrangement 3. Determination of teaching contents 4. Problems to be given attention to in teaching 5. Teaching contents and requirements of compulsory physics curriculum 6. Teaching contents and requirements of compulsory and optional physics curriculum 7. Assessment 8. Appendix : Examples of research topic	Teaching objectives

Note: Curriculum documents issued in the same year are merged in the frequency change diagram. If there's no division of junior and senior high school in the outline, the competence will be counted twice. The final statistical results are 4 for junior high school and 3 for senior high school.

Table 5 Structure of China's different editions of physics curriculum standards for secondary school and the location of target text from the new curriculum reform to the present (2001 to 2017)

Year	Name	Overall structure	Location
2001	*Physics Curriculum Standards for Full-time Compulsory Education(Experimental Draft)*	1. Preface 2. Curriculum objectives 3. Standards for contents 4.Suggestions for implementation	Curriculum objectives
2003	*Physics Curriculum Standards for General Senior High School(Experiment)*	1. Preface 2. Curriculum objectives 3. Standards for contents 4. Suggestions for implementation	Curriculum objectives
2011	*Physics Curriculum Standards for Compulsory Education*	1. Preface 2. Curriculum objectives 3. Standards for contents 4. Suggestions for implementation	Curriculum objectives

2017	*Physics Curriculum Standards for General Senior High School*	1. The nature and basic concepts of the course 2. Core literacy and curriculum objectives 3. Curriculum structure 4. Curriculum contents 5. Academic quality 6. Suggestions for implementation	Core literacy and curriculum objectives

Note: The final statistical results are 2 for junior high school and 2 for senior high school.

The research consists of two major stages. First, the high-frequency words in the curriculum standards of a certain period help to reflect the characteristics and trends of curriculum development at the stage, and the analysis of high-frequency is of high value to interpret the competence-oriented requirements in the curriculum standards. The research of the first stage is carried out according to the four developmental stages of China' s centennial physics curriculum standards for secondary school. With the help of the word frequency statistics function of the Nvivo 11--qualitative analysis software, based on the distribution characteristics of co-occurring words, we explore the characteristics of the stage development of China' s centennial physics curriculum (Curriculum documents issued in the same year are merged, and if there's division of junior and senior high school, the curriculum documents will be counted separately). In the second stage, based on the framework of disciplinary competence assessment constructed in this paper, we analyze the evolution of disciplinary competences in the target texts of China's physics curriculum standards for secondary school from the following five dimensions: basic ability, comprehensive ability, problem solving, epistemology and creative thinking, so as to explore the development process of the requirements for disciplinary competences in China's centennial physical curriculum standards.

4 Results

4.1 Stage characteristics of the development of China's physics curriculum standards for secondary school

The high-frequency words in the physics curriculum standards for junior high school at the first stage（1902-1948）of the development of China's physics curriculum standards for secondary school are science, students, observation, experiment and physics, reflecting the physics curriculum at this stage focused on teaching students scientific knowledge, which served as scientific enlightenment. As an exotic natural science subject, physics initially focused on knowledge, and then research methods as well. The main role of the physics curriculum at this stage was to popularize scientific knowledge (figure 2). The frequency of "physics" and "students" increased (Figure 1), and physics gradually separated itself from science, starting paying attention to students. At first, the frequency of "observation" was higher than that of "experiment", then with the development of physics, the frequency of "experiments" gradually increased, even exceeded "observation". The target text required students to learn basic laws and systematic physics knowledge meanwhile prescribed experimental materials and precautions. At the beginning of the second stage (1949-1987), the Outline of Physics Teaching for Secondary School(Draft), which was drafted with the reference to the former Soviet Union, got issued in1952(figure 3). At this stage, the high-frequency co-occurrence words in physics curriculum standards for the junior high school were experiments, students, physics, learning, and technology while for the senior high school, they were students, physics, experiments, sports, laws, and applications. The focus at this stage was on preparing students for making contribution to the country and deepening their understanding of materialism, movement and change, and causality, which base the further study of modern science and technology as well as the mastery of modern production skills. The high-frequency co-occurrence words in physics curriculum standards for the junior high school at the third stage (1988-2000) were students, physics, experiment, understanding and learning, with a high frequency of "students", reflecting the focus on students' learning of physical concepts and their understanding of physical knowledge. The target text stipulated that the task of general secondary school was to cultivate young people with ideals, morals, culture and discipline (figure 4). The high-frequency words in physics curriculum standards for senior high school were students, physics, movement, experiments, laws and application, with the focus on physical concepts and regular teaching. Exposing students to physical experiment methods, physics teaching followed the strategic thinking of modernization, world-oriented and future-oriented so as to equip students with comprehensive physics knowledge and get them prepared for the construction of the country, to cultivate innovative talents for the country, and to make contribution to the continuous economic development. At the fourth stage (2001-2017), in order to follow the trend in the international development of science education, the curriculum standards after the new curriculum reform clearly proposed the following several points: attach importance to lifelong learning and the cultivation of students' scientific inquiry ability; based on students' development, reflect the student-surrounded teaching style and the power of physics curriculum in promoting social development; build and improve the evaluation system, including principles, task design and method, tapping the incentive potential of evaluation (Ministry of Education, P. R.China, 2011). Core literacy of physics, a new expression in the 2017 Physics Curriculum Standards for Senior High School, aimed to cultivate students' disciplinary literacy and competences based on the subject itself. It stipulated 21 experiments that students must perform and increased the frequency of "experiments". In a word, it paid more attention to students' development (Ministry of Education, P. R.China, 2017) .

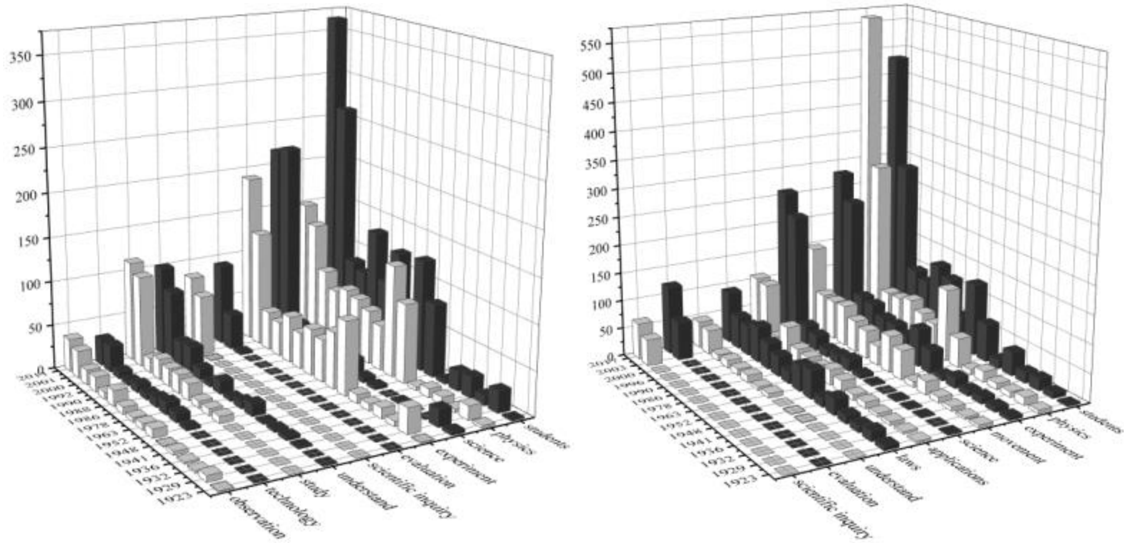

Figure 1 The change of high-frequency co-occurrence words in physics curriculum standards for the secondary school (left: junior high school, right: senior high school)

4.2 The Change of disciplinary competences in China's centennial physics curriculum standards for secondary school

First of all, our research finds that the requirements for basic ability and comprehensive ability always sit at the core of China's physics curriculum standards for secondary school and appear in the first part of the target text. In the 2001 and 2011 editions of physics curriculum standards for junior high school and the 2003 edition of physics curriculum standards for senior high school, the first dimension was aimed at knowledge and skills. The same applied to the latest 2017 edition, namely "master the concept of substance, movements and interactions, energy, etc., and can use the knowledge to explain natural phenomena and solve practical problems". The basic ability and comprehensive ability have been changing stably, and the frequency of the requirements for basic ability is higher than those of comprehensive ability (figure 3 and 4).

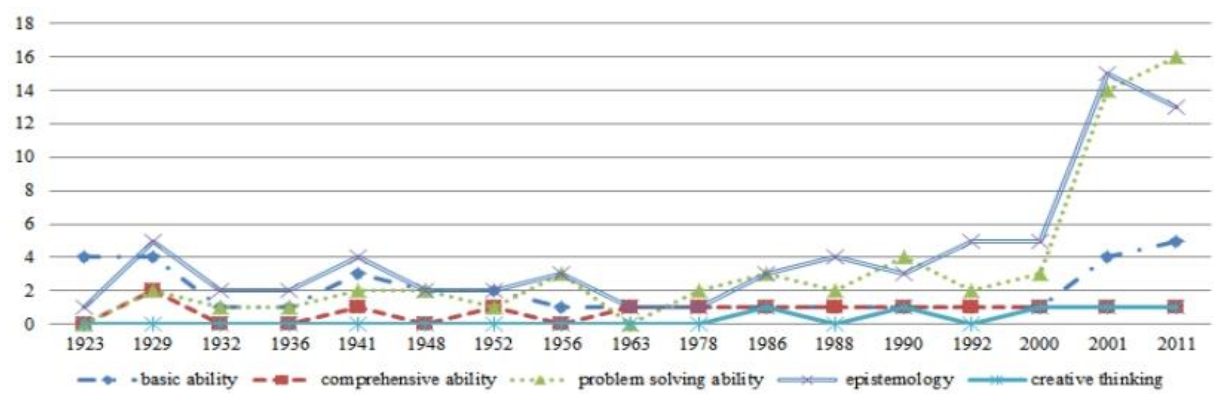

Figure 3 The frequency change of disciplinary competences in the target text of China's centennial physics curriculum standards for junior high school

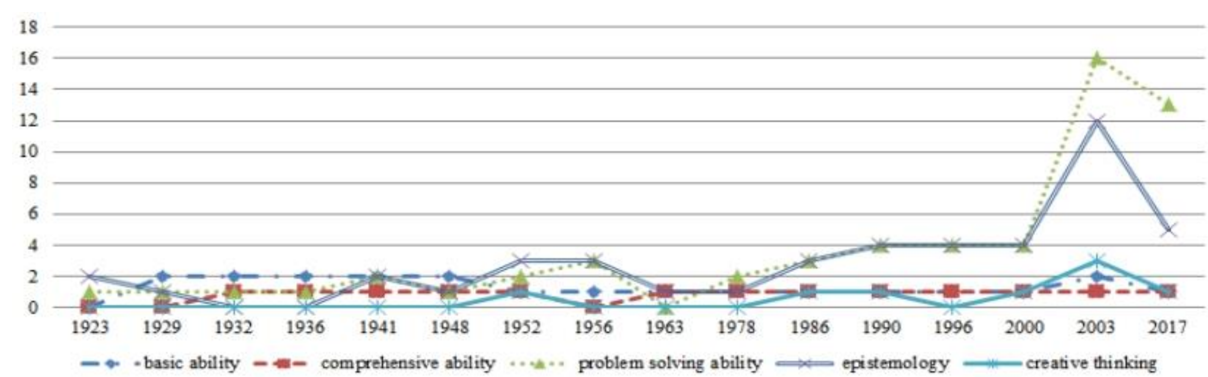

Figure 4 The frequency change of disciplinary competences in the target text of China's centennial physics curriculum standards for senior high school

Second, the requirements for problem-solving ability are growing diverse and clear. Throughout the evolutionary trend of disciplinary competences of physics in secondary school, the changes of the requirements for problem-solving ability and epistemology are the most obvious. Except the curriculum outlines in 1923 and 1963, all the outlines have these two requirements for students (figure 3 and 4). Physics is an experiment-based natural science subject, in which the experimental operation plays an essential role. The requirements for students' ability in experimental operation in the junior high school were first proposed in the 1948 edition of Revision of Curriculum Standards for Physics And Chemistry in Junior High School(figure 5). From the founding of the People's Public of China to the new curriculum reform, there were no explicit requirements for the ability in experimental operation in the physics curriculum standards. In the 2001 and 2011 editions of physics curriculum standards for junior high school, there were respectively 4 and 2 requirements for the ability in experimental operation, along with requirements in aspects like question-raising, plan-making, data-collecting and-processing, and report-writing. Compared with the classification of the curriculum standards in 2001, the 2011 edition was more comprehensive, which not only put forward requirements from the perspectives of experimental operation and scientific inquiry, but also raised the safety consciousness in experimentation. The requirements for students' ability to cooperate and communicate in junior high school first appeared in the 2001 edition of Physics Curriculum Standards for Full-time Compulsory Education(Experimental Draft), and the 2011 edition was basically the same. The requirements concerning the sub-dimension of the scientific methods, namely the utilization of scientific methods, were put forward in 1929. Due to ambiguous expression, it gradually faded out of the public focus. And the attention didn't come back until the issue of Outline of Physics Teaching for Secondary School(Trial Draft) in 1978, which required students to use mathematics to solve physical problems. With the emergence of scientific inquiry after the eighth new curriculum reform, scientific methods got gradually enriched. The requirements for the cultivation of students' thinking ability first appeared in the Outline of Physics Teaching for Secondary School(Trial Draft) in 1978. In the 2001 and 2011 editions, the requirements concerning the sub-dimension of cognitive thinking got explicit and enriched with a focus on the raise of students' scientific consciousness such as the consciousness to apply research methods, the consciousness concerning sustainable development, etc.. The ability in experimental operation in curriculum standards for senior high school appeared relatively early with emphasis on the precision of observation in 1923(figure 6) and had higher requirements than those of junior high school. In the 1948 edition of Revision of Physics Curriculum Standards for Senior High School, the requirements for the ability in experimental operation, including experimental principles, data, instruments and results processing, got considerably enriched and the experimental report appeared for the first time, which, however, didn't get much attention until after the new curriculum reform when the requirements concerning this dimension appeared. The development trend of cooperating and communicating abilities are the same as those of junior high school except for more attention to the thinking before communication and the accuracy of expression. The scientific methods were put forward in 1929, but were one-sided and mechanical. The attention paid to scientific methods increased after the founding of the People's Republic of China, and the contents also got enriched after the new curriculum reform. It's one of the characteristics of China's physics curriculum standards for secondary school to emphasize scientific methods. The requirements concerning cognition and thinking and problem-solving ability go the same as those of junior high school, except for more attention to former one.

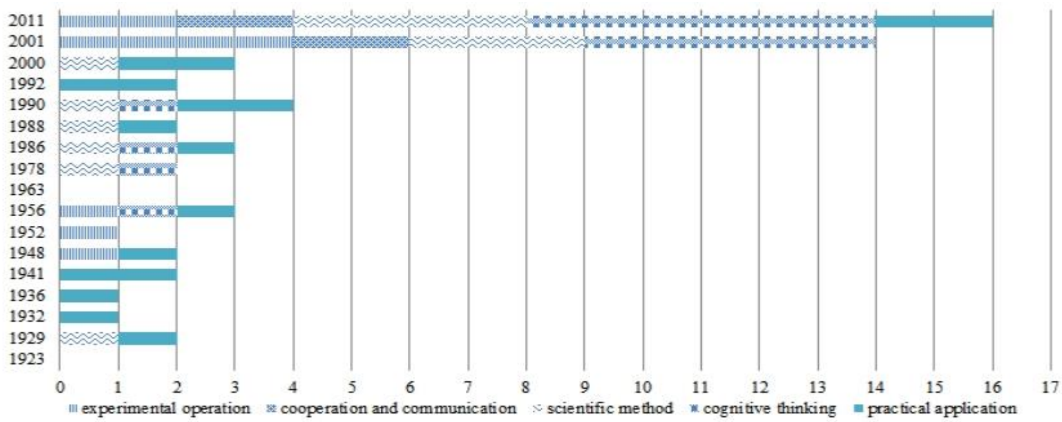

Figure 5 The frequency change of the requirements for the second level problem-solving ability in the target text of the physics curriculum standards for junior high school

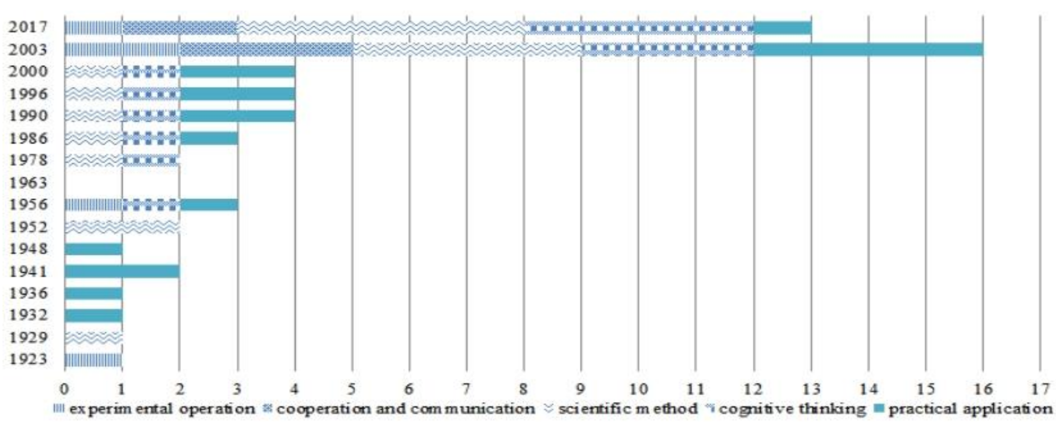

Figure 6 The centennial frequency change of the requirements for the second level problem-solving ability in the target text of the physics curriculum standards for senior high school

Third, the requirements for epistemology-oriented ability go from none to being increasingly prominent. On the whole, the requirements for epistemology-oriented ability in China's physics curriculum standards are on the rise and the junior high school gets more requirements than the senior high school, especially in the terms of emotions and attitudes (figure 7). After the new curriculum reform, the parts of emotions, attitudes and values in the three-dimensional goals of China's curriculum standards belongs to the epistemology-oriented dimension. The 2003 edition of Physics Curriculum Standards for Senior High School clearly stated that after the new curriculum reform, the requirements for epistemology-oriented ability is of unprecedented importance, and the development trends of both junior and senior high school stages are basically the same, but there remain obvious differences when it comes to specific dimensions. In the curriculum standards for junior high school, the cultivation of students' emotions, attitudes and values is always in an significant status. Emotions and attitudes point to learning interests while values concern materialism, patriotism and the sense of duty for society and the environment(figure 7); In the 2001 and 2011 editions of curriculum standards, the attention to students' emotions and attitudes got unprecedentedly increased, and there were also requirements for students' inner feelings and external performances. Although there's no obvious change in the requirements for students' personality, the expression was totally different--from good observation habit to research spirits, and then to study habits and thinking habits. In a word, there is a potential increase in the requirements for the cultivation of students' personality. There's little mention of the nature of the subject in the early stage, and it's not until 1988, the third stage, that it came into public focus. The expression always centered on the contribution of physics to social and national development. In the curriculum standards of the new century, the understanding of the physics subject itself was included. The most required part in physics curriculum standards for senior high school remained emotions, attitudes and values (figure 8), but less than those of the junior high school stages. The early focus was on the cultivation of students' learning interests and scientific attitudes, while in the 1996 and 2000 editions of physics curriculum standards for high school, it moved to students' aspirations and interests. For the two editions of curriculum standards after the new curriculum reform, there were requirements in terms of interests, attitudes, spirits, etc.. While emphasizing patriotism, they also required scientific attitudes of seeking truth from facts. The attention to the requirements for understanding the nature of physics got increased after the 1996 edition of curriculum standards. Compared with junior high school stages, the requirements for students' understanding of the relationship between physics and other subjects were added, and more attention was paid to the requirements for disciplinary knowledge. The 2017 edition of Physics Curriculum Standards for General Senior High School required students to "correctly understand the nature of science" with further requirements for disciplinary knowledge. For students' personality, in the early stage, the emphasis was placed on observing habits and questioning spirits, and later on the development of good thinking habits.

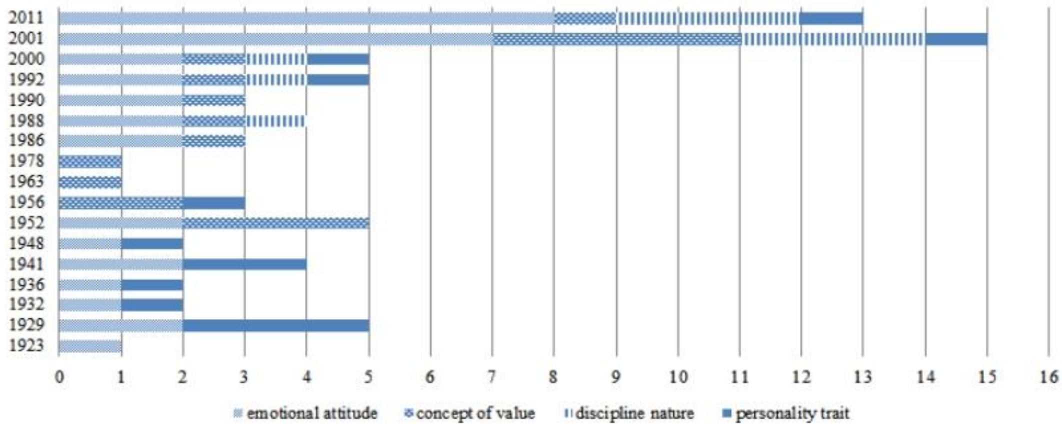

Figure 7 The frequency change of the requirements for the second level epistemology-oriented ability in the target text of the physics curriculum standards for junior high school

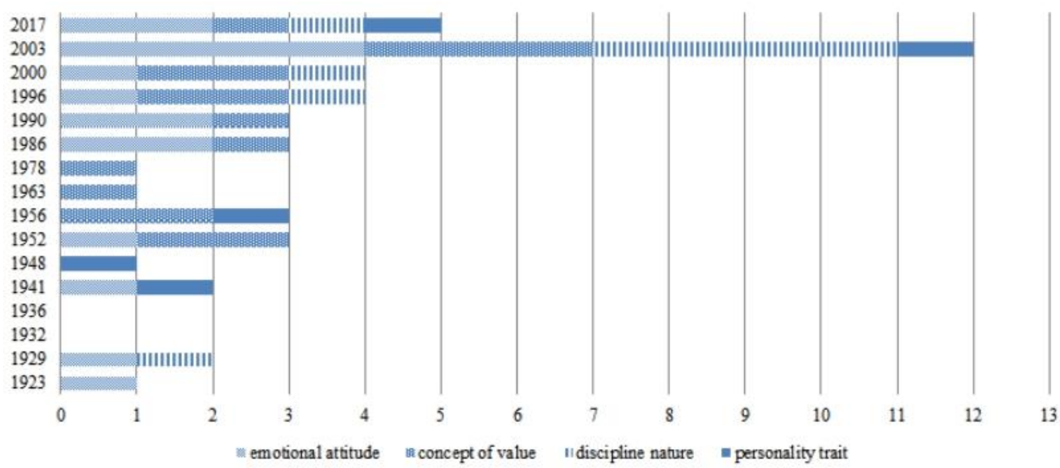

Figure 8 The frequency change of the requirements for the second level epistemology-oriented ability in the target text of the physics curriculum standards for senior high school

Fourth, the competence-oriented requirements in the physics curriculum standards are increasingly associated with science, technology, society, and the environment. STSE, which consists of science, technology, society and environment, values the role of science and technology in social production, living environment and social development. As a member of science subjects, physics serves as a significant driving force for the development of science and technology. The STSE education is in an increasingly important status in the competence-oriented requirements. The relationship between physics and science was first mentioned in the 1932 edition of Physics Curriculum Standards for Senior High School, and later in 1941, the document mentioned the relationship between physics and society and stated "students are required to get some inkling of the relationship between physics and national defense". In the 1978 edition of Outline of Physics Teaching for Secondary School(Trial Draft), the relationship between physics and technology was mentioned in the elaboration of basic ability, which was joined by "preliminary knowledge about the relationship between resource utilization and environmental protection" in the later 2001 edition. Thus, the educational idea of STSE had been fully established in the physics to improve students' scientific literacy in all respect.

5. Discussion

First of all, China's physics curriculum standards for secondary school attach importance to individual development and the cultivation of competences with subject characteristics. Generally speaking, students, physics and experiments in the physics curriculum standards for secondary school are of great concern. The curriculum standards after the founding of the People's Republic of China further identified the requirements for physics experiments. After the reform and opening up, more attention was paid to science, technology and students' value orientation. In 1987, the State Education Commission stressed the importance of non-intellectual factors in teaching. The attention to students in the physics curriculum standards for senior high school experienced a qualitative and quantitative leap in 2001 and 2017, while for junior high school, it's in 2001 and 2011. Scientific attitudes, scientific methods, scientific inquiry, etc. started to gain attention in the curriculum standards. The emphasis in the junior high school stages is on the teaching of preliminary physical knowledge and inquiry into qualitative relationship, and the physical knowledge in senior high school gets deepen and enriched with a focus on quantitative relationship.

Second, the competence-oriented requirements go from being single, separate, vague to being pluralistic, integrated and explicit. First of all, the type of requirements for disciplinary competences gradually grows from being single to being pluralistic. For example. In 1923, the requirements for basic ability were of the most concern, and later in 1929, there's an increase in the requirements for epistemology-oriented ability, together with the appearance of problem-solving ability. In 1952, basic ability, epistemology-oriented ability, and problem-solving ability were all required; after 1978, problem-solving ability and epistemology-oriented ability amounted to the top of concern. After the eighth curriculum reform, the emphasis moved to lifelong learning, scientific inquiry ability, innovation consciousness and the cultivation of scientific spirits and newly added creative thinking. Second, the earliest edition of the curriculum standards for junior high school only focused on students' mastery of disciplinary knowledge. In 1948, the requirements for students' understanding of the relationship between national survival and physical knowledge was put forward for the first time and the comprehensive ability was required in 1952. In 2003, the ability in experimental operation was proposed in the dimension of comprehensive ability, reflecting the integration trend of abilities. Finally, the requirements for students' abilities in the physics curriculum objectives for junior high school are on the rise. After the founding of the People's Republic of China, the requirements for students' competences have increased significantly and since the beginning of this century, the quality of competence-oriented requirements has risen rapidly and is growing more specific. The curriculum standards for senior high school play an increasingly important part in guiding the implementation of the curriculum. The role of physics has shifted from the popularization of scientific knowledge to the teaching of physical knowledge, then to the cultivation of disciplinary core literacy.

Third, the value orientation of the curriculum standards in different historical periods varies from each other. At the first stage of the centennial evolution of the physics curriculum standards, the curriculum standards from 1923 to 1929 focused on students' development. The 1923 edition reflected the needs of society while the 1929 edition took into account the needs of the subject in terms of of value orientation. Although the competence-oriented value orientation at the first stage concerned three aspects, the focus was still on the needs of students, followed by society and the subject; The basic ability, comprehensive ability and problem-solving ability at the second stage still centered on students' development with several statements about the cultivation of students' patriotism, and more emphasis was laid on the value orientation featuring competence development for social needs while less on the value orientation concerning disciplinary needs; at the third stage, there were quite a few occurrences of the requirements for innovation ability which belongs to the value orientation concerning social needs which were different from those of the second stage despite their shared value orientation; the curriculum standards at the first two stages showed obvious social values while the latest two editions of the curriculum standards at the fourth stage emphasized the physical knowledge necessary for lifelong development with the value orientation gradually turning to students' needs.

Fourth, consolidate basic ability, attach importance to problem-solving ability, and encourage epistemology and creative thinking. The cultivation of basic ability has always been emphasized in the centennial physics curriculum standards for secondary school, and the requirements for this ability are reflected in disciplinary knowledge and function. The comprehensive ability, which changes based on the needs of social development, emphasizes the value of physical knowledge in the lower grades while in the higher grades, the emphasis shifts to instrumental value. The core of problem-solving ability has moved from students' operational ability and scientific methods to cognition and thinking as well as cooperation and communication, and the core of epistemology has also moved from arousing interests to developing personality, quality and attitude in a comprehensive way. The requirements concerning emotions and attitudes in junior high school aim to arousing students' interests, and they get implemented throughout the whole learning progression; the requirements concerning values were first proposed in 1952 with focus on the cultivation of students' dialectical materialism, and was later joined by patriotism and the sense of duty to protect the environment, conserve resources and promote sustainable development; after 2000, the scientific attitude of seeking truth from facts got involved,too. In 1988, the nature of the subject was put forward as follows: to understand the role of physical knowledge in improving people's lives, promoting the development of science and technology, and constructing socialism, which was joined by environmental protection this century. For the personality and quality part, it required for the cultivation of students' good moral character and good habits. It was not until 1948 that there were requirements for senior high school students to cultivate positive research spirits and moral norm. The encouragement for independent thinking and creative spirits in physics curriculum standards for junior high school was first proposed in 1986, the cultivation of students' innovative spirits in 2000 and the innovation consciousness in 2001. The 1952 edition of curriculum standards for high schools put forward the idea of creativity inspiration, which got further emphasized as the cultivation of creative thinking after the reform and opening up. In 2017, it finally encouraged students to question and pursue technological innovation.

6. Conclusion

The research shows that in the centennial revolution of China's physics curriculum standards for secondary school, the requirements for students' ability go from being single, separate, vague to being pluralistic, integrated and explicit, and the disciplinary competences of physics are growing integrated. In teaching practice and research, teachers need to conduct staged assessments for students' various abilities in their learning progression and identify the level of core competences at a certain learning stage, so as to learn timely about the development of students' disciplinary competences of physics and their difficulties. Second, in different historical periods, the value orientation of physics curriculum standards for secondary school is different. The study of curriculum value orientation cannot be divorced from social and educational situation. However when it comes to implementation, the value orientation in the curriculum standards is not exactly the same as that of schools. Schools tend to implement curriculum policies on the premise of pursuing academic achievement, which will result in deviation in the performance of value orientation in the curriculum standards. Finally, the requirements for cooperation and communication ability, mainly pointing to the cooperation and communication in scientific inquiry, are put forward after the eighth new curriculum reform. Cooperation came to focus as an important element of scientific inquiry, and requirements in this aspect allow students to experience collaborative inquiry. Still there remain some challenges like how to realize the transition from problem solving to cooperative problem solving, how to infiltrate cooperation into problem solving, how to realize cooperative competition in group activities through group collaboration, and how to improve students' problem-solving ability, all of which are worthy of in-depth research in their specific implementation.

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