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# Research on 70 years Development of Mathematics Competence Requirements in Chinese National Curriculum: A Text Analysis on High School Mathematics Curriculum Standards Since the Founding of P. R. China

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ABSTRACT

This paper conducted a systematics text analysis research of 70 years Chinese mathematics curriculum standards for secondary schools since the founding of the People's Republic of China in 1949. Based on the bibliometric research of word frequency in the curriculum target texts, the content changes of curriculum standards were analyzed. A competence assessment framework was established to analyze the Chinese math curriculum target texts, and the characteristics of 70-year competence requirements development in Chinese mathematics curriculum standards were also summarized. Generally speaking, the goals of the high school mathematics curriculum in China are more and more comprehensive. From the emphasis on the mastery and application of knowledge to the focus on students themselves, individual students' ability and literacy have been emphasized more and more. Their learning process and emotional development are considered increasingly important. Mathematics also evolved from a tool to a science. However, the variety of abilities is also improved, the cultivation of cooperative communication ability needs to be stressed further.

## 1. Literature review

Mathematics is a basic discipline, which is originated from ancient Greece. It is a science that studies such concepts as quantity, structure, change and spatial models, which is widely used in the development of science and technology as well as in real life. In the era of intelligence, with the advancement of educational modernization, mathematics is also the key element in artificial intelligence. In the early years, there was less attention worldwide paid to math curriculum standards. Noyce (2001) investigated that standards-based mathematics programs can better replace more traditional curricula. Students using standards-based middle school math curriculum materials achieved higher math scores than students with similar prior math scores and family income levels in other school districts (Reys, Reys, Lapan, & Holliday, 2003). These studies have brought increasing attention to the importance of course standards. Later, researchers began to focus on the quality of math curriculum standards and consistency with teaching. During the 1990s, the teaching of mathematics became the subject of heated controversies known as the math wars. Schoenfeld (2004) described the background and history, and proposed some suggestions for the reform stimulated by the National Council of Teachers of Mathematics' Curriculum and Evaluation Standards for School Mathematics. And Polikoff (2015) indicates the textbooks studied systematically overemphasize procedures and memorization relative to the standards, among other weaknesses. The findings motivate further research on curriculum alignment. Dingman (2016) emphasized the growing role of curriculum standards as part of a standards-based education reform strategy, and the authors call on mathematics education researchers to carefully analyze curriculum standards and support education professionals to improve learning opportunities for students. At the same time, researchers are also beginning to study the actual impact of standards-based math courses on student achievement. Budak (2015) selected appropriate study participants using a range of conventional curricula on the mathematics assessment, and finds that the revised Investigations curriculum was not as effective with the low SES African-American students as it was for middle to high SES, white students. The curriculum fidelity measures did not differentiate achievement differences.

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China Knowledge Network was also chosen for the research texts. The search centers on "theme" (accurate), and the key search terms are "mathematics curriculum standards" and "mathematics syllabus". A total of 1,953 related documents were retrieved, among which 1455 articles were kept for further analysis after our manual deletion of the repeated documents. According to these high-frequency words, the research can be classified into three categories: the first one is concerning the contents of mathematics curriculum standards; the second is about the mathematics curriculum goals; and the third is concerning the mathematics teaching design. The research on the mathematics curriculum standards is mainly comparative research. The key words are mainly general senior high schools, textbook analysis, new curriculum standards, new textbooks, mathematics teaching, mathematics learning, mathematics class. The contents of curriculum standards in different countries became the research focus, involving the compiling characteristics of different curriculum standards in different countries, the purpose of which was to find out the reference points from other countries' curriculum standards, and the comparing of the curriculum contents of different edictions in China. Based on the mathematics curriculum standards, textbooks or knowledge arrangements were compared. The key words in the research of the mathematics curriculum goals are mathematics teachers, curriculum reforms, mathematics education reform. In this category, the research mostly centered on primary schools and junior high schools. Wang and Lu (2000) compared the similarities and differences of the mathematics curriculum objectives in these three countries, and suggest to set up the goal system for mathematics curriculum. Song (2003) analyzed the target system in the standards from six aspects: the concept of curriculum reform, the verbing of the curriculum objectives, the outlook on knowledge and the attitudes of students. Zhang (2013) analyzed the presupposition and value issues, construction and structural characteristics, management and adjusting of mathematics curriculum objectives, to provide reference for construction of the mathematics curriculum target system. In the third category of mathematics teaching design research, the key words are mathematics education, mathematics teachers, mathematics teaching activities, instructional design, mathematical thinking and methods, mathematics learning process, preliminary ideas. Yang (2014) presentation three-dimensional objectives in the process of teaching design.

There is not much research on the disciplinary competence required in the mathematics curriculum standards in China. Guo, Cao, Yang, and Liu (2015) introduced the two-dimensional evaluation framework, process, technical indicators and feedback forms based on the curriculum standards, concluding that the discipline competence test is different from the academic ability test. Jiang (2016) compared relevant research on the evaluation of mathematics competence at home and abroad, interpreted the elements of competence mentioned in the mathematics curriculum documents of Australia, the United States and Germany and got some enlightenment for the construction of the mathematics competence in China. Chen (2018) interpreted the mathematics curriculum concepts and objectives in the mathematics curriculum standards in Shanghai and Japan.

The basic information such as the frequency, centrality and initial occurring year of the key words related to the mathematics curriculum standards from 1988 to 2019 was generated (Table 1). Further analysis showed that the existing research focused on the mathematics curriculum standards, and the most frequent research was about senior high schools, followed by primary schools. Besides the curriculum standards themselves, mathematics teaching, mathematics teachers and mathematics learning are also popular. Comparative studies, mathematics courses, instructional design and classroom teaching are also the mainstream research topics. In recent years, much attention has been given to mathematics class and classroom teaching as well as mathematics learning of primary school students. It can be seen that the researchers of mathematics curriculum standards in China have shifted their focus from the contents of curriculum standards to mathematics teachers and mathematics learning, mathematics courses, and to the research in teaching design and comparisons home and abroad, and finally to the classroom teaching. The research has gone through a process from top to down, from texts to classrooms. In summary, in view of the study of K-12 mathematics curriculum standards, and the situation of China have proposed a new round of curriculum standards based on core literacy in 2018, the research questions of this paper are as follows:

Firstly, since the founding of the People's Republic of China 70 years ago, what is the development stage of Chinese mathematics curriculum standards in high school? Secondly, what kind of framework can be used to analyze the high school mathematics curriculum standards? Thirdly, what are the developmental status and characteristics of the discipline competence of Chinese high school mathematics curriculum standards since the founding of the People's Republic of China 70 years ago?

**Table 1.** High frequency and high centrality keywords (partial)**.**

| No. | Key words | Frequency | Centrality | Initial year |
|---|---|---|---|---|
| 1 | Mathematics curriculum standards | 856 | 1.14 | 1992 |
| 2 | Mathematics syllabus | 174 | 0.24 | 1992 |
| 3 | Senior high school mathematics | 113 | 0.18 | 2001 |
| 4 | Mathematics education | 96 | 0.06 | 1999 |
| 5 | Course standards | 67 | 0.03 | 2000 |
| 6 | Mathematics education | 67 | 0.13 | 2000 |
| 7 | Primary school mathematics | 52 | 0.07 | 2010 |
| 8 | Mathematics teachers | 44 | 0.01 | 1999 |
| 9 | General senior high schools | 42 | 0.01 | 2004 |
| 10 | Mathematics learning | 32 | 0.03 | 2002 |

## 2 Research Method

From 1902 to 2017, China published a total of 75 documents on national mathematics curriculum standards. In order to find the development of high school mathematics curriculum standards in these 70 years, 21 texts of mathematics curriculum standards (Institute of Curriculum Materials, 2001; Ministry of Education of P. R. China, 2001; 2003; 2011; 2017) published after 1949 were selected. Based on the in-depth longitudinal analysis and interpretation of the texts of discipline goals, this paper tried to review the development of the disciplinary competence required and conveyed in these math curriculum standards.

In the first stage, a total of 21 curriculum standards were selected (table 2). Secondly, based on the word frequency changes in high school mathematics curriculum standards, the development of the Chinese mathematics curriculum standards can be divided into two stages: the first stage covering the founding of the PRC to 2000 and the second one involving the 21st century. The school year system in this stage was comparatively diverse. The mathematics system in the early days of the founding of PRC was mainly based on the syllabus of the Soviet Union. After 1963, China began to develop independently. Chinese doubled-based (basic knowledge and ability) education and the systematic nature of the mathematics knowledge became the main features of the mathematics course (Lv, Yang, & Lin, 2015). The high-frequency words appearing at this stage are

equations, which appeared in 11 texts of the curriculum standards, but after 1990 its appearance frequency greatly decreased. At the same time, the curriculum standards began to emphasize the concept of knowledge (as a high-frequency word, it appeared in 7 texts of the curriculum standards) and nature (as a high-frequency word, it appeared in 12 texts of the curriculum standards), showing that the curriculum standards began to pay attention to the cultivation of students' correct ideas. Teaching, mastery and understanding are also new high-frequency words at this stage. At the same time, in this period attention has also been paid to teaching requirements and teaching methods. In the second stage, a total of 4 curriculum standards were issued, including two compulsory education mathematics curriculum standards and two senior high school mathematics curriculum standards. The focus of this stage has been transferred from teaching to students themselves, regarding students as the main body and emphasizing the students' learning process. Students, mathematics and problems are the words with the highest frequency. It can be seen that the discipline nature and operability of the mathematics curriculum standards have been enhanced and closely related to the problems in the real life. It is worth pointing out that in the General Senior High School Mathematics Curriculum Standards published in 2017 a high-frequency word literacy has newly appeared, meaning that the cultivation of students' morality, ability, level and spirit are stressed.

**Table 2.** The editions of Chinese secondary school mathematics curriculum standards in 70 years.

| | |
|---|---|
| 1949~2000 | 1950 Mathematics Simplified Outline (Draft) |
| | 1951 "Draft Standards for Junior High School Mathematics" |
| | 1952 "Syllabus for Mathematics in Junior High Schools" |
| | 1954 "Junior High School Mathematics Syllabus (Revised draft)" |
| | 1956 "Junior High School Mathematics Syllabus (Revised draft)" |
| | 1956 "Senior High School Cartography Syllabus" |
| | 1963 "Full-time Junior High School Mathematics Syllabus (Draft)" |
| | 1978 "Full-time Ten-year Junior High School Mathematics Syllabus (Trial draft)" |
| | 1980 "Full-time Ten-Year Junior High School Mathematics Syllabus (Trial draft)" |
| | 1982 "Full-time Six-year Key Junior High School Mathematics Syllabus" |
| | 1986 "Full-time Junior High School Mathematics Syllabus" |
| | 1988 "Nine-year Compulsory Education Full-time Junior High School Mathematics Syllabus (First draft)" |
| | 1990 Full-time Junior High School Mathematics Syllabus (Revised draft) |
| | 1992 "Nine-year Compulsory Education Full-time Junior High School Mathematics Syllabus (Trial version)" |
| | 1996 "Full-time General Senior High School Mathematics Syllabus (Trial version)" |
| 21st century | 2000 "Nine-year Compulsory Education Full-time Junior High School Mathematics Syllabus (Trial version)" |
| | 2000 "Full-time General Senior High School Mathematics Syllabus (Revised edition)" |
| | 2001 Compulsory Education Mathematics Curriculum Standards |
| | 2003 Full-time General Senior High School "Physics Curriculum Standards" |
| | 2011 Compulsory Education Mathematics Curriculum Standards |
| | 2017 "General Senior High School Mathematics Curriculum Standards" |

In junior high school, the ability to use mathematics as a tool in life is cultivated. The status of problem-solving ability is obvious, and epistemology ranks second. High school students began to pay attention to the cultivation of mathematical thinking, so that students can develop from application to application, so the basic ability and creative thinking gradually rich, problem solving ability and epistemology also began to emphasize the formation of thinking. The mixed stage of middle and high school is an exploratory stage. After 1978, the requirements of various abilities tend to be stable, and the comprehensive ability and innovative thinking have not received enough attention. Finally, through analysis, we get the development trend of discipline ability training. The basic ability develops from cultivating single type ability to improving students' comprehensive subject skills. Comprehensive ability from the use of mathematical tools to use mathematics as a tool for scientific research or other disciplines. Problem-solving ability focuses on the connection between middle and high school, and gradually develops mathematical thinking. Epistemology develops from the pure cultivation to the moral practice opportunity for students. The position of creative thinking will be enhanced to apply mathematics knowledge creatively to other fields

**Table 3.** The high-frequency words in high school mathematics curriculum standards in 70 years

| Titles in a time order | first | second | third | fourth | fifth | sixth |
|---|---|---|---|---|---|---|
| 1950 Mathematics Simplified Outline (Draft) | Fraction (21), equation (21), ratio (21), simplified (21) | | | | Exercise (20), application (20), root (20) | |
| 1951 "Draft Standards for Junior High School Mathematics" | Equation (135) | Trigonometric function (64) | Method (62) | Multiplication (61) | Function (56), student (56) | |
| 1952 "Syllabus for Mathematics in Junior High Schools" | Students (86) | Geometry (48) | Triangle (47) | Equation (45) | Nature (44) | Area (42) |
| 1954 "Junior High School Mathematics Syllabus (Revised draft)" | Students (85) | Triangle (49) | Geometry (46) | Nature (45) | Plane (43), equation (43) | |
| 1956 "Junior High School Mathematics Syllabus (Revised draft)" | Students (88) | Triangle (65) | Nature (58) | Application (57) | Equation (46) | Learning (44) |
| 1956 "Senior High School Cartography Syllabus" | Cartography (47) | Students (38) | Projection (37) | Homework (34) | Practice (32) | Teaching (24) |
| 1963 "Full-time Junior High School Mathematics Syllabus (Draft)" | Equation (84) | Nature (83) | Students (78) | Knowledge (64) | Teaching (59) | Mastering (55), straight line (55), lecture (55) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1978 "Full-time Ten-year Junior High School Mathematics Syllabus (Trial draft)" | Nature (53) | Function (47) | Equation (38) | Mathematics (31) | Teaching (30), straight line (30), knowledge (30) | |
| 1980 "Full-time Ten-Year Junior High School Mathematics Syllabus (Trial draft)" | Nature (62) | Function (53) | Equation (40) | Straight line (35) | Triangle (30), knowledge (30) | |
| 1982 "Full-time Six-year Key Junior High School Mathematics Syllabus" | Function (92) | Equation (90) | Nature (85) | Teaching (59) | Formula (55), Mathematics (55) | |
| 1986 "Full-time Junior High School Mathematics Syllabus" | Students (196) | Nature (133) | Concept (114) | Mastering (107) | Equation (103) | Function (95) |
| 1988 "Nine-year Compulsory Education Full-time Junior High School Mathematics Syllabus (First draft)" | Students (117) | Triangle (101) | Concept (101) | Nature (97) | Teaching (96) | Mastering (91) |
| 1990 Full-time Junior High School Mathematics Syllabus (Revised draft) | Students (199) | Nature (116) | Concept (108) | Master (104) | Requirements (94) | Equation (86) |
| 1992 "Nine-year Compulsory Education Full-time Junior High School Mathematics Syllabus (Trial version)" | Students (113) | Learning (94) | Concept (91) | Triangle (89) | Mastering (88) | Nature (84) Teaching (84) |
| 1996 "Full-time General Senior High School Mathematics Syllabus (Trial version)" | Mastering (98) | Teaching (91) | Function (79) | Mathematics (76), concept (76) | | Straight line (68) |
| 2000 "Nine-year Compulsory Education Full-time Junior High School Mathematics Syllabus (Trial version)" | Students (107) | Learning (94) | Triangle (87), mastering (87) | | Nature (85) | Concept (82) |
| 2000 "Full-time General Senior High School Mathematics Syllabus (Revised edition)" | Teaching (90) | Mastering (86) | Mathematics (83) | Function (72) | Learning (67) | Student (63) Concept (63) |
| 2001 Compulsory Education Mathematics Curriculum Standards | Students (251) | Mathematics (248) | Questions (168) | Learning (99) | Process (95) | Activities (87) |
| 2003 Full-time General Senior High School "Physics Curriculum Standards" | Mathematics (771) | Student (571) | Questions (343) | Methods (246) | Contents (243) | Learning (235) |
| 2011 Compulsory Education Mathematics Curriculum Standards | Students (641) | Mathematics (347) | Questions (291) | Process (194) | Learning (173) | Activities (166) |
| 2017 "General Senior High School Mathematics Curriculum Standards" | Mathematics (1159) | Students (572) | Questions (529) | Function (419) | Literacy (315) | Course (312) |

In the third stage, based on the framework of the Program for International Student Assessment (PISA), Bloom's classification theory of educational goals and Gagne's classification theory of learning outcomes, the discipline competence in the above 21 texts of the curriculum standards is divided into five types: basic ability, comprehensive ability, problem- solving ability, epistemology and creative thinking (Table 4). Basic ability is a single ability in discipline learning, referring to the basic skills such as calculation and mapping-making ability with which students can adapt to social life. Comprehensive ability is a process-based skill, that is, the ability to apply what has been learned into practice, and it does not involve cognitive thinking. Problem-solving ability refers to the ability to apply various cognitive activity skills in a certain situation, according to a certain goal, and solve problems through a series of thinking operations, including cooperative communication, cognitive thinking, scientific methods and practical application. Epistemological ability is the influence of the personal knowledge acquisition process on things like values, emotional attitudes, discipline nature and personality quality. Creative thinking ability is the innovative consciousness and innovative spirit in thinking activities. It can be seen that the basic ability, comprehensive ability and problem-solving ability highlight the instrumental function of mathematics, while epistemological and creative thinking abilities emphasize the educational function of mathematics in emotion cultivation. This study uses the curriculum objectives of 21 high school math curriculum standards. Each text is coded separately, and the data for each dimension of each subject's ability is counted.

**Table 4.** Classification of discipline competence in high school mathematics curriculum standards.

| Ability classification | | Specific descriptions |
|---|---|---|
| Basic ability | | Students can recognize, remember, understand discipline concepts, nouns and related knowledge, and calculate and make maps. The whole process involves only the input of knowledge and students' understanding, which is the most basic ability from mathematics. |
| Comprehensive ability | | Students can express their knowledge through actions or body language after mastering basic abilities. In this process, students have little involvement in cognitive thinking. For example, students can use computing instruments, measure instruments, and adapt to society. |
| Problem-solving ability | Cooperation and exchange | Through cooperation, communication, experience, participation, etc., students can solve problems, or can gain the ability of cooperation, social participation and mathematical expression in the process of solving problems. |

| | | |
|---|---|---|
| | Cognitive thinking | Students can use the knowledge they have learned, or can analyze and solve mathematical and practical problems through logic thinking, abstracting, imaging and other ways of thinking, and can form certain mathematical concepts, thus to develop correct thinking. |
| | Scientific methods | Students can learn certain scientific methods in the process of discipline learning, such as reasoning, and use these methods to solve practical problems. |
| | Practical application | Students can put forward questions from the perspective of mathematics, apply the knowledge they have learned to the solution of actual production and life problems, form the basic strategies for solving problems, accumulate experience in solving problems, and develop practical ability. |
| Epistemology | Values | Students can realize the transformation of their attitudes and the development of better outlooks on the world and life through discipline learning, practice and emotional experience in the learning process. |
| | Emotional attitudes | Through learning, students can enhance their love for the discipline, discover the contents of interest, and generate intent to learn the discipline in depth. |
| | The nature of discipline | Through study, students can base themselves on the discipline itself, understand the meaning and value the existence of the discipline, and appreciate its aesthetic value. |
| | Personal quality | Through learning, students can continuously promote the cultivation of scientific spirit, the development of their own quality and the improvement of personality, and gradually become more complete people. |
| Creative thinking | | Through learning, students can independently think, creatively explore and solve problems in learning and life. |

## 3 Result

The developing characteristics and changes to the ability requirements in junior high school curriculum standards, senior high school curriculum standards and the the mixing stage of junior and senior high schools were summarized. Firstly, in junior high school, it gradually highlighted the instrumental function of mathematics (figure 1). More emphasis was laid on problem-solving ability which was the most significant change. It paid more attention to the application of mathematics in real life and regarded mathematics as a tool to solve life problems. In terms of basic abilities, the descriptions in the three editions of 1988, 1999 and 2000 curriculum standards are basically similar. All of them stressed the mastering of basic knowledge and the skills in calculation and mapping. They paid more attention to teaching students experience and knowledge concerning daily life and social production, helping them develop fast calculation ability and good drawing habits in order to meet the needs of social development. There is a lack of simple reasoning in the 1992 curriculum standard compared with the other two, which had obvious changes in description, emphasizing the need of mastering the basic knowledge and skills in space and graphics, numbers and algebra, statistics and probability, and the mastery and application of knowledge. In terms of comprehensive abilities, the 20th century did not have detailed requirements. In the 2001 edition, it suggested that students should "experience the process of asking questions, collecting and processing data, making decisions and forecasting" and have the ability to solve simple problems. In 1986, the Compulsory Education Law was proposed. Therefore, in 1988, the curriculum standard began to attach importance to students' problem-solving ability, epistemology and creative thinking. In 1988, it proposed students' independent thinking ability and innovative spirit, but later there was not much development and change.

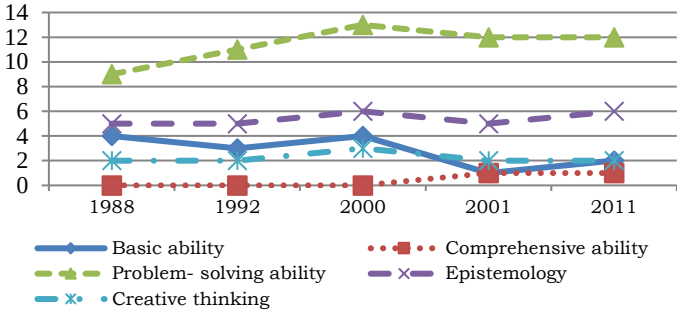


**Figure 1**. Discipline competence required in junior high school mathematics curriculum standards

In terms of problem solving, the ability of cooperation and communication has been paid attention to since 2001 (figure 2). The ability of communication refers to the process and result of presenting their thinking in the 2001 edition but the ability of cooperation was not mentioned. As to the cognitive thinking ability, after the founding of the PRC, there is a detailed description for it, including space concept, logical thinking ability, expressing ability, observation and analysis ability, reasoning ability, experimenting ability; in the 21st century, besides the above abilities, individual abilities, including abstract thinking, image thinking, spatial concepts, statistical concepts, expressing ability, evaluation and reflection abilities were also mentioned. In terms of mastering scientific methods, the development of this ability was very stable from 1988 to 2000. Three scientific methods for reasoning were proposed for mastery: induction, deduction and analogy; the 21st century curriculum standards did not elaborate on scientific methods in detail, and only emphasized the development of proper reasoning and deductive reasoning.

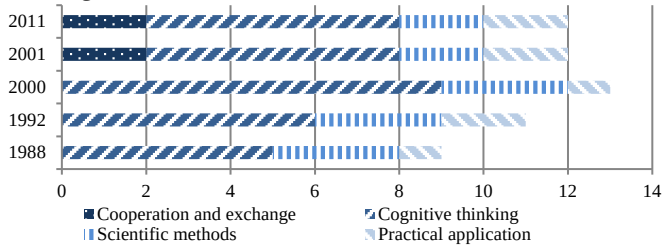


**Figure 2.** Problem-solving skills required in junior high school mathematics curriculum standards

In terms of practical applying ability, after the founding of the PRC, the ability to apply the knowledge they have learned to solve simple practical problems was emphasized (figure 3). The 1992 edition emphasized the abstraction of practical problems into mathematical problems and the cultivation of analytical and problem-solving skills; in the 21st century it is required that students should raise questions, understand them and solve them from a mathematical perspective. It can be seen that in the 1988 edition, there was a full description of problem-solving ability, and attention was paid to the formation of mathematical concepts, the cultivation of thinking ability and application ability. The use of scientific methods for reasoning was emphasized, and the systematic training of the reasoning ability was highlighted, but the ability to cooperate and communicate did not receive much attention. In 2001, for the first time, the cultivation of the communication and cooperation ability was mentioned, which was a turning point in the junior high school stage. In the 21st century, the description of each ability is more general. Basic illustrations were provided for most of the abilities. Students are required to learn to find and solve problems from the perspective of

mathematics. It can be seen that in the cultivation of abilities in this period the nature of mathematics has been increasingly stressed and its instrumental function has been increasingly recognized.

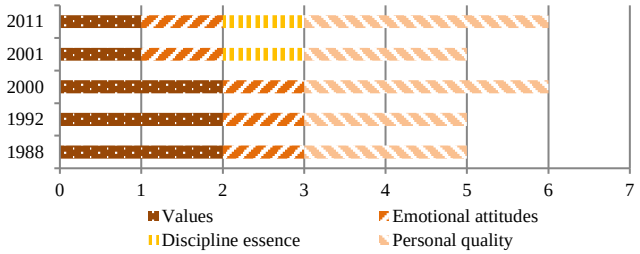


**Figure 3.** Epistemological ability required in junior high school mathematics curriculum standards

In 1986, the Compulsory Education Law was proposed in China. The State Education Commission highlighted the specific requirements of the new education policy. The mathematics curriculum reform entered the period of compulsory education. Therefore, in 1988, the curriculum standards began to attach importance to the cultivation of students' epistemological ability. In terms of values, in 1988, the focus was on the cultivation of the dialectical materialism world outlook and the scientific attitude of seeking truth. In the 21st century, the cultivation of the world outlook was not mentioned in the curriculum standards, but the description and explanation of scientific attitudes were included. In terms of emotional attitudes, most of the curriculum standards in junior high school attached importance to the stimulation and cultivation of learning interests of students. In essence, the 2001 curriculum standard began to require students to initially understand the connection between mathematics and life and the role of mathematics, experience mathematical activities, and feel the rigor of mathematics as well as the certainty of mathematical conclusions; in 2011, this ability was expressed more briefly, namely "the ability to experience the characteristics of mathematics and understand the values of mathematics." In terms of personal quality, from 1988 to 2000, developing students' personal quality had been increasingly recognized and stressed, from spiritual training to individuality training; at the same time self-confidence in learning mathematics was added to the standard; in the 21st century, the key role of the mathematical activity process has been realized. It is stressed that in the process of mathematics activities, students' curiosity should be stimulated, so that students can understand the characteristics and beauty of mathematics, thus tempering their will, building their self-confidence, and developing their individuality.

Secondly, it values the ability of mathematical expressing and thinking in the senior high school curriculum. According to the curriculum standard in 1956, students were supposed to learn the methods of drawing and its standards, learn to use the drawing tools and develop a certain spatial sense, based on which they could form spatial shapes on the plane. There were no requirements for other aspects. After 1986, in the mathematics course, students reached a high level in basic knowledge learning and basic ability training. However, there were still problems in the connection between junior high and senior high schools. Therefore, the State Education Commission promposed the "Full-time General Senior High School Mathematics Teaching Outline" (Trial version) and hence various abilities began to develop greatly. First of all, in basic abilities, the 1996 edition required students to master the basic knowledge of algebra and geometry, preliminary knowledge of probability statistics and calculus, form basic skills and strengthen their computing power. In 2000, the ability to draw charts was added. In terms of comprehensive abilities, the data processing abilities were mentioned and illustrated in both the 2000 and 2003 editions. With the continuous development of science and technology, China's science and technology talent policy has entered a period of rapid development since 1992 (Li, & Zhang, 2011). In 2000, it was further required that schools should cultivate students' sense of innovation, develop their exploring spirit, and improve their independent thinking skills. Although the previous editions of the curriculum also mentioned mathematical thinking and expressing, the emphasis on the ability to express mathematical thinking was the most evident in all the curriculums.

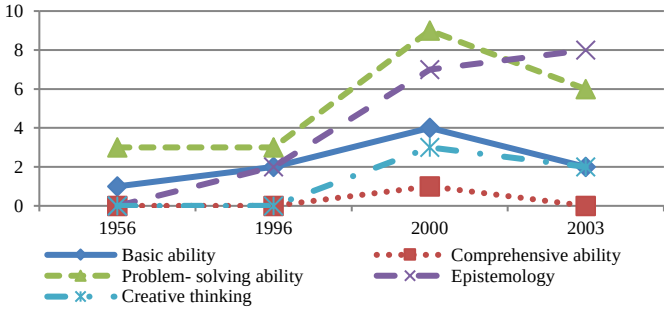


**Figure 4.** Discipline competence required in senior high school mathematics curriculum standards.

The development period of problem-solving skills is more ups and downs, but the overall situation is constantly being improved (figure 5). The ability to cooperate and communicate, i.e. using mathematical language to express problems and communicate, was only mentioned in the 2000 and 2003 editions. The description of cognitive thinking ability in the curriculum standard was very simple, and each ability or concept was detailed. In 1956, developing students' spatial concepts and imagination was proposed. In 1996, spatial concepts and imagination were merged into one concept spatial imagination, meanwhile thinking ability was proposed and added to the curriculum. In 2000, the concept of thinking ability was further enriched, requiring students to express their ideas logically and accurately, identify the mathematical relationships with the help of mathematical concepts, ideas and methods and form good thinking qualities which can help them observe, compare, analyze, synthesize, abstract and generalize. The curriculum standard of the 2003 version changed the thinking ability in space imagination into space imagination, and revised the thinking ability into forming a critical thinking habit. In terms of scientific methods, the 1956 curriculum standard was for cartographic teaching, so it required more on geometric knowledge, i.e. mastering the main methods of expressing spatial forms on the plane. It was not until the year 2000 that it was connected with the junior high school curriculum standards, requiring induction, deduction and analogy for reasoning. In practical applications, it was only in the late 20th century that attention was paid to the application of the learned knowledge, that is, solving practical problems in life. The curriculums in the 21st century not only emphasized the cultivation of application ability, but also emphasized mathematical thinking ability.

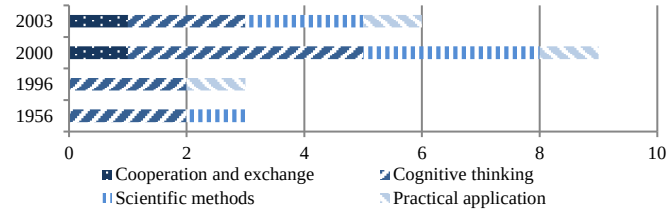


**Figure 5.** Problem-solving skills required in senior high school mathematics curriculum standards

When it comes to the ability of cooperation and communication, students in junior high schools are the key trained targets. For students in senior high schools, the cultivation of their thinking ability should be more stressed; in

terms of the cognitive thinking ability, cultivating the abstract thinking should be increasingly important, and in this process, scientific attitudes were supposed to be formed. In terms of scientific methods, the requirements for senior high school students are low, and the types of scientific methods required to be mastered are limited; the time for the cultivation of practical application ability was later than that in junior high schools. Junior high schools attached importance to mathematical strategies and the application of knowledge, while senior high schools emphasized the comprehensive application of mathematical thinking and the connection with other disciplines.

The status of epistemology has also been continuously improved with time (figure 6). The secondary dimensional values involve the dialectical materialist, scientific attitude and historical materialism world view, which were in turn proposed in 1996, 2000 and 2003, respectively. In terms of emotional attitudes, all the curriculum standards emphasized the cultivation of students' interest in learning mathematics. In the nature of discipline, the 2000 edition required students to experience mathematics aesthetics; in 2003, besides aesthetic values, scientific, applicable and cultural values of mathematics were identified and valued. Compared with the junior high school stage, the State paid more attention to the experience of the nature of mathematics in senior high schools, aiming at stimulating students' interest in learning and cultivating their scientific spirit and scientific attitude towards research. In terms of personal quality, from 1996, the formation of good personal quality, the improvement of learning confidence and perseverance were emphasized. In 2000, the spirit of mathematics was reemphasized, and for the first time "advocating the rational spirit of mathematics" was proposed. The latest version of senior high school mathematics curriculum standards issued in 2017 is based on the theory of core literacy. Aiming at the cultivation of good personal qualities, schools are supposed to develop the core competence of students in the mathematics discipline.

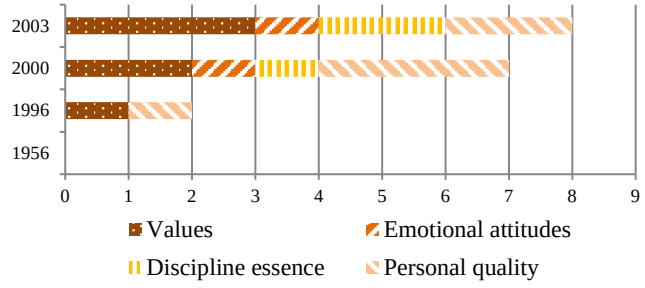


**Figure 6**. Epistemological ability required in junior high school mathematics curriculum standards

Thirdly, 11 related documents were issued in the junior and senior high school, and ability and awareness training had mutual action. Figure 7 shows the developing trends of various abilities required in the target texts of mathematics curriculum standards in the mixed stage of junior and senior high schools. In general, the formulation of the curriculum standard at this stage before 1978 was in the exploration stage, focusing on the application of mathematics, lacking the cultivation of thinking quality, mathematics consciousness and the instrumental function of mathematics. Until 1978, the development of various abilities required in the curriculums became stable. Basic ability requirements varied, but the general requirements were constant. From 1950 to 1963, although the expressions were different, there was a tendency to lay an emphasis on the mastering of knowledge in the textbooks; in 1978, the application of basic knowledge of mathematics into modern science and technology was emphasized. Comprehensive ability and creative thinking were only mentioned in the curriculum standards promulgated in 1956, and creative thinking was only at the level of cultivating creativity.

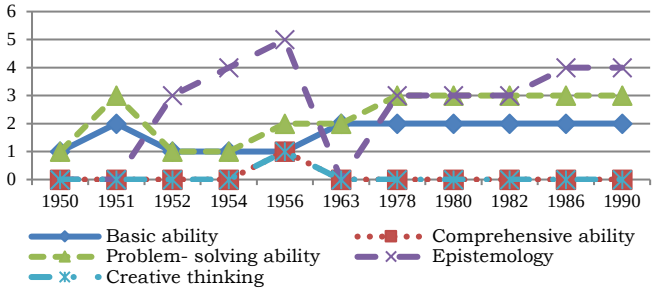


**Figure 7.** Discipline competence required of the curriculum standards in the mixed stage

It can be seen from Figure 8 and Figure 9 that the requirements in those years were uneven, sometimes there being requirements for the problem-solving ability and sometimes there being a lack, which further confirms an overall continual exploring process at this stage, but the requirements for individual ability were not clear (figure 8). At this stage comprehensive abilities, cooperation and communication abilities, etc. were relatively weak. The nature of the discipline was not fully understood. In terms of problem-solving ability, the aspect of cooperation and communication was not mentioned in any curriculum standards in the mixed school stage. In cognitive thinking, in 1951, teachers were asked to inspire students' dialectical thinking; after 1956, both logical thinking and spatial imagination were required, and there were no changes to the ability description. In terms of scientific methods, only the curriculum standard proposed in 1951 pointed out that it was necessary to cultivate students' scientific habits and spirit of exploration in analysis, induction, judgment, reasoning, etc. This requirement is actually a precedent for the cultivation of students' mastering scientific methods in reasoning in the junior and senior high schools. In practical application, in 1950, "theory should be linked to practice" and "learn to use" were proposed; the meaning was further explained in 1951, that is, training students to familiarize themselves with tools (nouns, tokens, theorems, formulas, methods) to enable them to carry out accurate calculations and solve practical problems; in 1952 only the ability to use knowledge to solve practical problems in life was emphasized, highlighting the practical value of mathematics; in 1954, the tradition was followed; after 1978, each curriculum standard required the gradual development of students' ability in analyzing and solving problems.

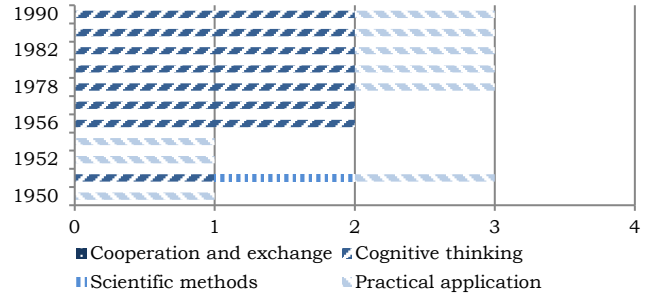


**Figure 8.** Problem-solving competence required in the curriculum standards in the mixed stage

In terms of epistemological values, the dialectical materialist worldview was proposed in 1952, and students were required to learn to participate in the socialist revolution and construction; in 1978. In 1980, the tradition was followed, and the cultivation of scientific attitudes was proposed in 1982 (figure 9). The nature of discipline was not mentioned in any of the above-mentioned curriculums. As the Chinese Communist Party started to build a socialist China, in terms of the emotional attitude, the idea was proposed in 1978 curriculum of providing ideological and political education to students and motivating them to be enthusiastic about learning mathematics to actively take part in the realization

of four modernizations, in response to the "four modernizations" proposed by the country. This tradition was continued in 1980 and 1982 curriculums; in 1986, the importance of stimulating students' interest in learning was re-recognized. In terms of personal quality, in 1952, it was proposed to cultivate students' patriotism and national self-respect and develop their strong will and character. Besides this, in 1954, the cultivation of students' love towards science, labor, the collective and self-discipline was added in the curriculum; in 1956, properly connecting with the situation and achievements of China's socialist construction in training students to actively participate in socialist construction was considered necessary in the curriculum.

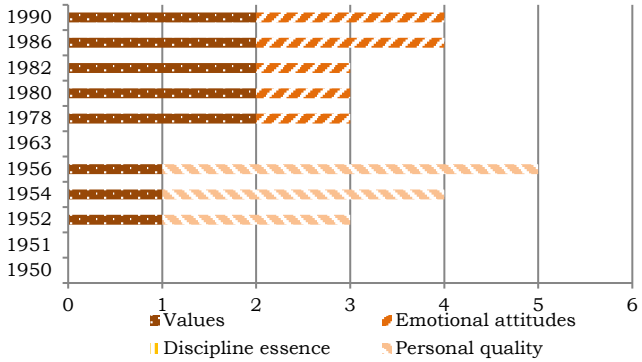


**Figure 9.** Epistemological abilities in high school curriculum standards of the mixed stage.

## 4 Discussion

Firstly, Basic abilities, such as discipline knowledge, skills and functions, have simultaneous development. The development of basic abilities can be analyzed from three aspects: subject knowledge, skills and functions. In terms of subject knowledge, the course curriculum initially required students to understand the nature and relationship of image and quantity, and then gradually move to specific knowledge, which emphasized algebra, geometry (planar geometry, solid geometry), triangle, integral fraction and scale, planar analytical geometry, probability statistics and calculus. And with the development of the society, the connection with the real life was gradually emphasized in the curriculum. In 1982, it was proposed to have a good command of the basic mathematics knowledge necessary for the construction of modern society and further study of modern science and technology. In 1986, besides mastering basic knowledge, the curriculum standards required students to support and implement the socialist system. In the 21st century, junior high school curriculum standards laid a focus on the basic knowledge of graphics and algebra, while senior high school curriculum standards proposed higher requirements in understanding the basic mathematical concepts and the nature of mathematical conclusions. In terms of subject skills, starting from the training of calculation and mapping ability, the ability to measure, raise questions, collect and process data, and make decisions is gradually strengthened. The development presents a trend from developing a single type of ability to enhancing students' overall and basic abilities. In terms of disciplinary function, in the beginning, students were hoped to increase their knowledge and experience in their daily life with the help of mathematics and then could use it as a tool for studying natural sciences.

Secondly, comprehensive ability has the transformation from the tool o skill application. The purpose of developing comprehensive ability was to help students adapt to the needs of social life and regard mathematics as a tool. Later, with the development of science and technology, related computing instruments, measuring instruments were used. In 1956, the emphasis was placed on "cultivating students' skills in using spreadsheets, computing instruments, measuring instruments and drawing instruments." It was not until the 21st century that people realized that mathematics is also the basis for studying other disciplines and other fields, and in some data processing, mathematics knowledge is also needed. Therefore, it was proposed to cultivate some calculating and data processing (including using a calculator) abilities according to certain procedures and steps. The proposal and development of comprehensive ability not only reflects the progress of science and technology in China, but also reflects the enhancement of people's research consciousness and the improvement of research level.

Thirdly, problem solving emphasizes the connection of stages and highlighting the basic ideas of mathematics. The problem-solving ability is mainly divided into four aspects. First, the ability to cooperate and communicate focuses on the connection of expressing skills among students of different ages and levels of knowledge. In 2000, the requirements for cooperation and communication ability were first proposed. This ability emphasized that in the junior high school students should learn to express and communicate in mathematical language. In the senior high school stage, students were generally required to express their own thinking process and results on the basis of cooperation. It can be seen that the junior high school students were required to communicate on the basis of describing ability, while the senior high school students were required to increase their logical thinking ability. Second, the development of cognitive thinking ability tended to be divergent. The development of this ability took the reasoning and analyzing ability as the starting point, moved to the concept of function and space, and finally into the basic ideas in mathematics and mathematical thinking ways, such as logical thinking ability, spatial imagination, number sense, symbolic awareness and so on. This ability training was mainly to train students to understand the mathematical relationship and form a good thinking quality. Third, scientific methods focused on the cultivating of induction, deduction and analogy, with the purpose of improving students' basic skills in abstract summarization and theoretical proof. Fourth, the practical problem-solving ability gradually shifted from the application of tools to the application of knowledge and skills, from passively solving problems to actively exploring problems, that is, from "using mathematical knowledge to solve practical problems" to "discovering problems, raising problems and solving them from mathematical perspectives.

Fourthly, epistemology is focused on the cultivation of individuality, moral quality and scientific attitude. On the basis of stimulating students' interest in learning, epistemological ability continuously emphasizes the cultivation of students' moral quality, and attaches importance to the development of students' individuality and scientific attitude. The development of epistemological ability has gradually become more comprehensive, aiming at the full development of students. In 1941, the revised Mathematics Curriculum Standards for Senior High Schools first mentioned the scientific spirit, standing for the beginning of cultivating students' scientific spirit and attitudes. In the 1950s, not only the cultivation of students' patriotism, but also the cultivation of students' strong will and characters in the teaching process were emphasized. In the 1980s, it was required to implement correct values in practice. Epistemological ability changed from simply providing opportunities for the development of students' morals to providing consistent quality moral education.

Fifthly, creative thinking is emphasized the integration of innovation consciousness and mathematics discipline. In 1956, creativity and flexibility were first proposed at the same time. In 1988, the idea of innovation was introduced, which was later called innovation consciousness. Beginning in 2000, the extended description of creative thinking required students to be curious, to

constantly pursue new knowledge, and to use mathematical methods to explore, research and solve. Curiosity and desire to get knowledge are both constantly promoting the formation and development of innovation consciousness. It can be seen that creative thinking was no longer simply proposed, but was linked to the mathematics discipline. It aimed to cultivate students' creative thinking ability, enhance their application of this consciousness in mathematics and their creative application of mathematical knowledge to other fields.

Generally speaking, from the emphasis on the mastery and application of knowledge to the focus on students themselves, individual students' ability and literacy have been emphasized more and more. Their learning process and emotional development are considered increasingly important. Mathematics also evolved from a tool to a science. In the 21st century, although the country attaches great importance to cultivating students' creative thinking, emphasizing the independent acquisition of mathematics knowledge in life, and the variety of abilities is also improved, the cultivation of cooperative communication ability needs to be stressed further.

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