An evaluation of the large-scale senior secondary science curriculum reform in China

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By

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Thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

School of Education

Durham University

April 2024

Abstract

This thesis aims to evaluate the new large-scale science curriculum in China. The large-scale reform changes curriculum, pedagogical content and assessment methods from 2016. This reform raises a concept new in China called ‘core competencies’ which intends to have a major change in curriculum and education system. The evaluation of this study aligns with the three-level curriculum framework: intended, implemented, and attained, which focuses on national context of this reform, experience from participators of this reform, including principals, teachers, and students.

A mix-method approach was employed in this study to better explore and evaluate the reform at different levels. For the intended curriculum, qualitative documentary analysis of official documents, curriculum standards, and textbooks could raise a context of this reform. For the implemented curriculum, perceptions of principals and teachers come to be vital for evaluation. Thus, interviews and thematic analysis can elicit their in-depth beliefs and attitudes. For the attained curriculum, Quantitative students’ science-related attitudes questionnaire data and qualitative interview data are collected to concrete what students is experiencing and evaluate the reform at the student level.

The research findings indicate that during the early stages of reform, policymaking still followed the pattern of the previous curriculum reform, taking into full consideration the current political, economic, and social factors in China and attempting to establish curriculum standards and comprehensive evaluation systems based on core competencies. However, these policies were not effectively translated into textbooks and school-based curricula. School principals need to balance the relationship between school management and curriculum leadership, facing many difficulties in implementing the new curriculum. Regarding the new curriculum, teachers are mainly limited to their understanding of subject teaching content and classroom management. In contrast, students have a more positive attitude towards the new curriculum reform; there are gender differences and grade differences in their science-related attitudes, but they are positive-minded.

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Abbreviations

CCRP	Core Competences Research Group
CCSS	Common Core State Standards
CIPP	Context, Input, Process, Product
DDDM	data-driven decision making
EU	European Union
MoE	Ministry of Education
OME	Ontario Ministry of Education
OECD	Organisation for Economic Co-operation and Development
P21	Partnership for 21st Century skills
UNESCO	United Nations Educational, Scientific, and Cultural Organization
6Cs	Fullan and Scott (2014)' six competences

Glossary of terms

Gaokao

Its full name is 'Nationwide Unified Examination for Admissions to General Colleges', The Chinese college entrance examination. Students take the college entrance examination at the same time (usually in June 7th-8th every year) across China. The examination papers have eight versions for different provinces, National Examination Paper volume I, National Examination Paper volume II, National Examination Paper volume A, National Examination Paper volume B, and four provincial self-proposed examination papers (details are shown as below).

The Type of National Examination Paper	Participating provinces
Volume I	Shandong, Fujian, Hubei, Jiangsu, Guangdong, Hunan, Hebei.
Volume II	Hainan, Liaoning, Chongqing*
Volume A	Yunnan, Guangxi, Guizhou, Sichuan, Tibet
Volume B	Henan, Shanxi, Jiangxi, Anhui, Gansu, Qinghai, Inner Mongolia, Heilongjiang, Jilin, Ningxia, Xinjiang, Shaanxi.
Provencal self-proposed examination paper (Beijing)	Beijing
Provencal self-proposed examination paper (Tianjin)	Tianjin*
Provencal self-proposed examination paper (Zhejiang)	Zhejiang*
Provencal self-proposed examination paper (Shanghai)	Shanghai

* The provinces of volunteer teachers in this study

Statement of copyright

Acknowledgements

During the process of completing this thesis, I received invaluable assistance and support from numerous individuals. Firstly, I would like to express my sincere gratitude to Professor Vanessa Kind, my supervisor, for her unwavering guidance and support throughout every stage of my PhD study. Her expertise not only provided valuable insights into the direction of my research but also offered comprehensive and meticulous advice on refining my paper. Her rigorous academic approach and profound knowledge have greatly influenced me. Through continuous communication and learning with Professor Vanessa Kind, I not only achieved breakthroughs in professional knowledge but also cultivated a solid foundation for critical thinking.

Secondly, I extend heartfelt appreciation to all other faculty members at the college who showed care and support during the study process. Their valuable opinions and suggestions were instrumental in resolving challenges promptly while organizing various specialized lectures, seminars, etc., which invited distinguished experts in relevant fields to share their experiences. This exposure allowed me access to cutting-edge theoretical advancements as well as practical wisdom.

Furthermore, I am grateful for the encouragement and understanding extended by all participating teachers throughout this entire research journey; together we made progress by sharing experiences and resources while overcoming difficulties and challenges.

Lastly yet significantly important, special thanks are due to my family for their unwavering support and endless encouragement! They have consistently been my most reliable pillar during busy or nervous times; providing affirmation and warmth when needed most; listening and advocating when encountering obstacles or confusion; rejoicing and praising even more than me upon achieving commendable results or recognition!

I would like to express my sincere gratitude to all those who have assisted me throughout this journey! While you may have crossed paths with me by chance, your genuine and friendly support has made my pursuit of knowledge more seamless and enjoyable. Thank you!

Chapter 1 Introduction

1.1 Rationale of this study

This thesis focuses on evaluating the new round of national curriculum reform in China. This curriculum reform involves the entire field of basic education and secondary education nationwide. This article primarily focuses on evaluating the curriculum reform in the high school stage, specifically in the subject of science. The last national curriculum reform took place in 2001, making this current one the second curriculum reform since the beginning of the 21st century.

I chose to research this topic for two main reasons:

Subjectively, I, as a student, experienced the last national curriculum reform firsthand, which was a stage of great significance. In this process, I deeply felt the impact of education reform on students and teachers. Through the new curriculum and teaching methods, I was able to develop my abilities and qualities in a more comprehensive way. Then, because of my interest and love for science, I chose to study chemistry in university. During my undergraduate years, I was exposed to a variety of laboratory practice and theoretical knowledge, and gradually realized the important role of science education in cultivating talents and promoting social progress. This made me more determined to engage in the education industry and carry out relevant research work.

After graduation, I have accumulated rich and valuable experience during the two years of working in the education industry. Through getting along with and communicating with students of different ages and backgrounds, I deeply realized that every child is a unique and precious individual, and it is crucial to give them correct guidance and care on their growth path. These experiences have turned my interest to the field of educational research. Through participating in various research projects and reading relevant literature, I began to think about how to optimize the existing educational model, improve the quality of teachers and promote the development of the overall society. I also realized that only by constantly exploring, reflecting and applying theories to practice can truly promote educational reform to achieve results.

Objectively, when I began to think about my doctoral topic in 2016, China's curriculum reform research group issued a report on ‘developing students' core competencies’ and began a new round of national curriculum reform around the new concept of ‘core competencies’ for China. This reform aims to change the exam-oriented education and form quality education and solve the problems of China's education development. However, for a long time, the problem of exam-oriented education has been a difficult and stubborn problem restricting the healthy development of China's education. It leads students to focus only on exam skills and knowledge memory, lacking practical application ability and creative thinking. Therefore, in the face of increasingly complex and changeable social needs, the traditional exam mode has been unable to meet the needs of students' overall development.

In response to this problem, ‘core competencies’ as a new concept has been introduced into the curriculum reform and has become one of the key elements to promote the transformation and upgrading of the entire system. ‘Core competencies’ emphasizes the cultivation of students' interdisciplinary abilities such as critical thinking, cooperative spirit, and innovation ability, and integrates them into various subject areas. In this way, it is hoped that the excessive pursuit of scores and rankings under the traditional one-dimensional evaluation system can be broken. However, there may be many difficulties and challenges in the implementation process. Firstly, how to establish evaluation standards and methods? Since ‘core competencies’ involves the cultivation of various abilities and qualities, how to quantify the evaluation is still an urgent problem to be solved? Secondly, how to provide corresponding support and resource arrangement? To really implement, the cultivation of ‘core competencies’ needs good environmental conditions, excellent teachers and effective supporting measures. Finally, it is necessary to strengthen home-school cooperation and social participation and make joint efforts to promote the curriculum reform at different levels.

Therefore, when I choose to conduct a comprehensive study and evaluation of the new round of curriculum reform, it is based on a sense of responsibility and a deep concern for the future development prospects of China's education. Through in-depth exploration and understanding of the opportunities and challenges behind the curriculum reform, and put forward feasible suggestions and solutions, I hope to make my own modest contribution to promoting China's education to embark on a more healthy and sustainable development path.

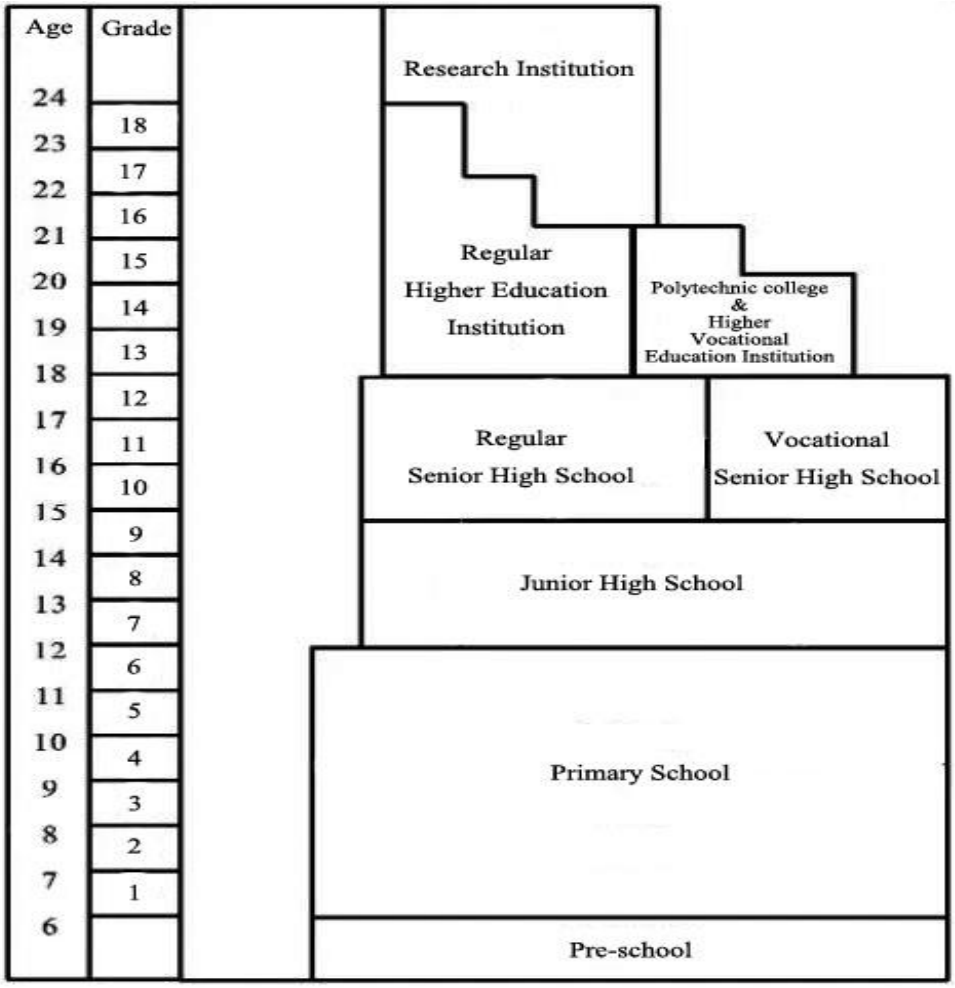
1.2 Research Background

1.2.1 *Introduction to the Chinese Education System and School Situation*

China's education system is divided into five stages (shown in **Figure 1.1**): preschool education, primary school education, junior high school education, senior high school education and higher education. Preschool education refers to the comprehensive training for children aged 3 to 6 years old, focusing on developing their social skills, practical abilities and cognitive abilities. Primary and junior high schools are important components of compulsory education. Primary schools provide basic knowledge and skills training for children aged 6 to 12 years old, helping them establish a solid foundation in language, mathematics and science.

Figure 1.1

Chinses Education System



Junior high schools further strengthen students' mastery of various subject knowledge systems and begin to guide them in forming independent thinking and problem-solving abilities. After completing junior high school graduation, students need to participate in the unified entrance examination (referred to as 'Zhongkao') based on their exam results and preferences to choose between regular senior high schools or vocational technical colleges for further studies. After three-year study in senior high schools last and earning credits from different subjects, they can take the national college entrance examination (referred to as 'Gaokao'). This study focuses on the implementation of curriculum reform in senior high school education during the stage of senior secondary schooling.

According to the latest 'Statistical Bulletin on the Development of National Education in 2022' (Table 1.1) released by the Ministry of Education of China, there are 17.313,800 students enrolled in junior high schools and 4.025,200 full-time teachers, with a student-teacher ratio of 12.72:1. There are 1,118,500 classes in junior high school. There are 4,522 large classes and super classes with more than 56 people, accounting for 0.40% of the total number of classes. Among them, there are 174 super classes with more than 66 people, accounting for 0.02 of the total number of classes. The gross enrolment rate (the percentage of students (regardless of age) in the 15-17 age group) at the senior secondary level was 91.6%. Among them, there were 15,000 regular high schools nationwide, with 9,475,400 students and 27.138,700 students. 2.1332 million full-time teachers of regular senior high school education (referring to those who undertake regular senior high school education in senior high schools, full secondary schools, senior high schools of the 12-year system and senior high school classes attached to other schools); The ratio of students to teachers is 12.72:1. At the stage of higher education, there are 3,013 institutions of higher learning, including 1,239 regular undergraduate schools, 32 vocational schools at the undergraduate level, 1,489 vocational (junior college) schools, 253 adult institutions of higher learning, and 234 research institutes for training graduate students. Regular undergraduate enrolment was 4.679,400, and specialized undergraduate enrolment was 866,200.

Table 1.1

Statistical report on China's educational status of Junior high schools, Senior high schools and Higher education in 2022

		The number of schools	The number of registered students	The number of new entrants in 2022	The number of graduates in 2022	The number of Faculty and staff	Student-teacher ratio
Junior high schools		52500	51206000	17313800	16239200	4025200	12.72:1
Senior high schools	Regular senior high schools	15000	27138700	9475400	8241000	2133200	12.72:1
	Vocational senior high schools	7201	13392900	4847800	3992700	718300	18.65:1
Higher education	Regular higher education institutions	1239	19656400	4679400+866200*	4715700	1315800	18.31:1
	Polytechnic colleges	32	228700	76300+33100*	-	27800	8.23:1
	Higher vocational education institutes	1489	16709000	5389800	4947700	619500	19.69:1

* The number following the plus sign denotes the number of students enrolled in the higher education institutions from the vocational senior high schools. (China, 2023)

Although the enrolment rate at high school level can reach over 90%, the development of regular senior high schools and vocational schools is currently unbalanced. Only about 60% of students can enter regular high schools for education, among which approximately 50% can proceed to undergraduate institutions. This development path for students is considered mature and safe by society and parents as a student's educational journey, especially for students and family from rural region in China. Therefore, the stage of regular high school receives widespread attention as an important part of student education development, and the importance of college entrance examinations to students and their families stems from this.

1.2.2 *Chinese Senior Secondary School System and Curriculum Settings*

According to the 2020 revised 'Curriculum Scheme for General High Schools' released in 2017, the duration of general high school education in China is three years. Each academic year consists of 52 weeks, with 40 weeks allocated for teaching, 1 week for social practice, and 11 weeks for holidays. Each class hour is calculated as 45 minutes, and it takes 18 class hours to earn one credit.

Meanwhile, high school courses are divided into three categories: compulsory courses, selectively compulsory courses, and elective courses. Compulsory courses refer to subjects that are set by the state based on students' developmental needs and must be studied by all students. Selectively compulsory courses are designed according to students' individuality and requirements for the Gaokao (refer to the National College Entrance Examination). Students who participate in Gaokao need to choose subjects based on their own interests and needs in order to fulfil graduation credit requirements (Shown in Table 1.2).

Table 1.2

Credits for compulsory, optional compulsory, and optional courses in senior high school in China

Subject	Compulsory	Optional Compulsory	Optional
Chinese	8	0-6	0-6
Mathematics	8	0-6	0-6
Foreign Language	6	0-8	0-6
Politics	6	0-6	0-4
History	4	0-6	0-4

Subject	Compulsory	Optional Compulsory	Optional
Geography	4	0-6	0-4
Physics	6	0-6	0-4
Chemistry	4	0-6	0-4
Biology	4	0-6	0-4
Technology	6	0-18	0-4
Art	6	0-18	0-4
Physical Education	12	0-18	0-4
Integrated practice	8		
Labour	6		
Total	88	No less than 42	No less than 14

Optional courses are developed by schools based on students' diverse needs, local social-economic-cultural development demands, as well as the characteristics of school management. Students have autonomy in selecting these courses for study.

1.2.3 *Subject selecting, Flexible Class Scheduling, and New Gaokao policy*

The new round of curriculum reform began in 2014, starting with the first batch of high school students enrolled in the autumn of 2014 in Shanghai and Zhejiang Province as pilot areas. They implemented new courses and college entrance examination policies. In 2017, Beijing, Tianjin, Hainan Province, and Shandong Province were designated as the second batch of regions to implement the reforms. In 2018, Hubei Province, Hunan Province, Chongqing City, Liaoning Province, Hebei Province, Jiangsu Province Guangdong Province and Fujian province were identified as the third batch of regions for implementing reforms. The remaining provinces and cities began implementing curriculum reform in 2022.

Subject selecting and New Gaokao policy

Instead of the previous '3+X' mode in the college entrance examination, the current '3+3' mode has been implemented. The first '3' remains unchanged, with Chinese, Mathematics, and English as the three compulsory subjects. Every student takes the same exam papers for these subjects. As for the latter '3', students can freely choose three out of six other subjects (History, Geography, Politics, Physics, Chemistry, Biology) based on their interests and strengths to be included in their level-based exams.

In these level-based exams, each subject has a maximum score of 100 points.

However, instead of displaying specific scores, grades are used to represent performance levels. The grading system is as follows: the top 5% of participants receive an A+, the next 10% receive an A grade; this pattern continues with B+, B-, C+, C-, D+, etc., each accounting for approximately 10%. Grades D and E account for around 15%, with E indicating a score below standard or approximately within the bottom 5%.

When calculating final scores for college admissions purposes, level-based exam results are converted into corresponding point values. For instance, A+ corresponds to 70 points while A corresponds to 67 points; each subsequent grade difference is three points lower than its predecessor until reaching E which corresponds to 40 points (equivalent to passing marks in high school academic proficiency exams).

New Gaokao schedules and formats have been implemented. Unlike before, as the first batch of curriculum reform, Gaokao held in Shanghai and Zhejiang Province is not concentrated in June of the third year of senior high school, but evenly distributed throughout different stages of senior high school. Additionally, for foreign language exams, there would be two tests conducted within a year, with the higher score being counted towards the total grade.

Flexible Class Scheduling

Implementing the rotating class system and flexible class scheduling, this is a measure that allows students to personalize their course selection while expanding the freedom of choosing classes based on individual interests. Due to potential variations in subject choices among each school and every student within each class, the '6 choose 3' grading exam design offers a total of 20 possible combinations. As a result, although the original class structure still exists, the personalized course selection mechanism has replaced the previous fixed-class model through its focus on selected subjects. In short, under the rotating class system, students attend classes in different subject classrooms based on their knowledge foundation, learning abilities, and personal interests while considering evaluations from various subject teachers. This is a new teaching model that combines fixed administrative classes with mobile subject-based instructional groups.

Table 1.3

Statistical report on Tianjin's educational status of Junior high schools, Senior high schools and Higher education in 2022

		The number of schools	The number of registered students	The number of new entrants in 2022	The number of graduates in 2022	The number of Faculty and staff
Junior high schools		341	361994	121167	106489	30737
Senior high schools	Regular senior high schools	191	209086	71652	58108	17959
	Vocational senior high schools	63	82867	27386	24853	5286
Higher education	Regular higher education institutions	30	375558	95048	90370	25900
	Polytechnic colleges and Higher vocational education institutes	26	218947	75655	65602	7486

Table 1.4

Statistical report on Chongqing's educational status of Junior high schools, Senior high schools and Higher education in 2022

		The number of junior high schools	The number of registered students	The number of new entrants in 2022	The number of graduates in 2022
Junior high schools		1120 (high schools)	1087500	350500	396700
Senior high schools	Regular senior high schools		663300	232100	205300
	Vocational senior high schools	128	379700	138100	106800
Higher education	Regular higher education institutions	70	1066100	350600	271000
	Polytechnic colleges and	-			

	Higher vocational education institutes						

Table 1.5

Statistical report on Zhejiang province's educational status of Junior high schools, Senior high schools and Higher education in 2022

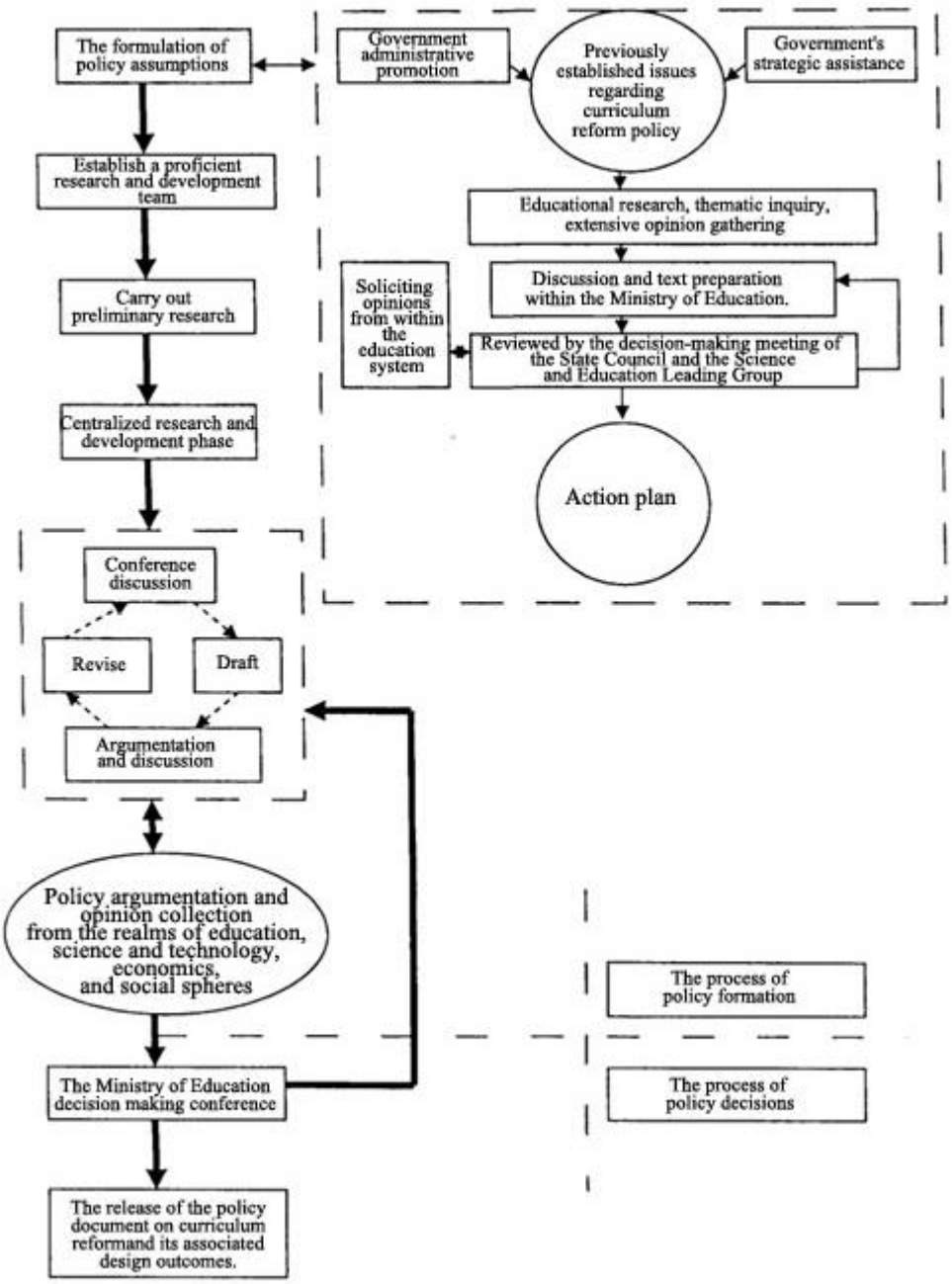
		The number of schools	The number of registered students	The number of new entrants in 2022	The number of graduates in 2022	The number of Faculty and staff	Student-teacher ratio
Junior high schools		1782	1692900	575700	106489	136700	12.4:1
Senior high schools	Regular senior high schools	641	864400	300000	58108	78300	11:1
	Vocational senior high schools	355	730200	237300	24853	38300	13.7:1
Higher education	Regular higher education institutions	58	705515	202277	171415	82111	-
	Polytechnic colleges	2	9503	6166	184	1654	-
	Higher vocational education institutes	49	538247	194021	174665	30144	-

1.2.4 *Formation and Determination of China's Curriculum Reform Policy*

According to the statistics summarized in the previous section, China's education industry has the characteristics of large scale and wide distribution. The implementation of a nationwide curriculum reform in China requires rigorous policy formulation and decision-making processes. The policy decision-making process for this curriculum reform is shown in Figure 1.2.

Figure 1.2

The fundamental procedure for reviewing the Chinese curriculum reform



1.3 Research Questions

To conduct a more comprehensive and in-depth study on the impact of this curriculum reform, I have proposed four main research questions.

1. What context is the new curriculum taking place and in what ways is the new curriculum distinct with the old one?

2. In what ways are high schools and science teachers implementing the new curriculum?

3. What is the impact of the new curriculum on high school students' science-related attitudes and how do students experience the curriculum reform?

4. What are the implications and further development from findings in this study?

To provide more organized and coherent answers to these four main research questions, each of them has been broken down into multiple sub-questions.

Sub-questions for research question one:

1a: What social and political circumstance is the new curriculum taking place?

1b: How do the new curriculum standards translate the official curriculum documents?

1c: in what ways is the new curriculum distinct with the old one?

Sub-questions for research question two:

2a: What are school principals' experience and perceptions on the new curriculum implementation?

2b: What are science teachers' experience and reflection on the new curriculum implementation?

2c: In what ways the practised curriculum differs from the planned curriculum?

Sub-questions for research question three:

3a: What is the impact of the new curriculum on high school students' science-related attitudes at the beginning of the curriculum reform?

3b: How do high school students experience the new curriculum?

The final research question is addressed in the last chapter, serving as a summary and outlook of the entire study.

1.4 Framework of this thesis

This thesis has seven chapters. Following the introduction chapter which has introduced the reason of topic selection and research background in China, Chapter 2 firstly reviews curriculum and curriculum change theory related to the context of curriculum reforms. Then, by reviewing the historical process of curriculum reform and development in China, I can not only understand the changes in curriculum philosophy, goals, curriculum plans, content, teaching methods, and curriculum evaluation but also comprehend the interconnections between curriculum and the nation, society, politics, economy, and even individual people. Finally, this study summarized the relevant curriculum framework and evaluation framework.

Chapter 3 focuses on research methods. In this chapter, I first refine the evaluation framework for curriculum reform in this study by analysing the research questions. Then, based on the framework, I discuss in detail the specific data collection and research analysis methods for each level of curriculum. Additionally, I provide a thorough discussion on the theoretical foundations of these methods and how they can be integrated into the research design of this paper, including documentary analysis, interviews with school principals and teachers, the group interview with students, and student questionnaires.

Chapters four, five, and six correspond to the data analysis sections of the first three research questions. Chapter four corresponds to the first research question and has two main tasks: firstly, conducting a policy text analysis on national policy documents released by the Ministry of Education prior to implementing curriculum reforms; secondly, comparing and analysing the new high school curriculum standards with the old ones. Chapter five corresponds to the second research question and primarily involves analysing data from principal interviews and teacher interviews. Chapter six corresponds to the third research question and mainly focuses on analysing data from student surveys and student interviews.

The final chapter is the summary and discussion section. In this chapter, I first summarised the findings from the previous three data analysis chapters and answer the research questions. Then, I combined these findings to engage in a thorough discussion to address the last research question, which pertains to the implications of this study and potential challenges that may arise during

subsequent curriculum reforms.

1.5 Summary

As the first chapter of this thesis, Chapter 1 introduces the intrinsic and extrinsic reasons for choosing this topic. Although China has a long history of education, the practice of modern educational development is still relatively short, and the accumulated experience is not sufficient. This curriculum reform is the second nationwide curriculum reform since the 21st century, representing an important milestone in China's attempt to absorb international educational concepts and embark on its own path of curriculum reform. The key to this reform lies in developing students' core competencies as the foundation for curriculum reform. How to integrate theory with curriculum is an important aspect in evaluating this curriculum reform. In the next chapter, I firstly reviewed curriculum theories and theories of curriculum reform, then explore the development path of core competencies theory through literature on core competencies. Finally, by examining it from a temporal dimension and social historical context perspective, I aim to find out the developmental trajectory of China's curriculum reform to have a more objective and dialectical understanding of this current curricular change and provide better answers to research questions.

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Chapter 2 Literature Review

2.1 Introduction

In this chapter, reviews firstly concentrate on curriculum and curriculum reform theories with the curriculum development in China and other regions worldwide. I discussed political, economic, social and educational context of curriculum reform in relation to large-scale curriculum development in China. Furthermore, I introduced China's current curriculum reform based on core competencies. Second, by incorporating reviews to conceptualize the structure of the science curriculum in China, I established a comprehensive curriculum framework for this study. The final section concentrates on existing models for evaluating curriculum within the context of defining the concept of curriculum evaluation, and subsequently integrates with the curriculum framework to propose a curriculum evaluation framework for this study.

In the first section, before reviewing science curriculum reform in China, I plan to discuss the definition of some concepts of curriculum and reform, especially in the situation of Chinese culture and history, which is importance of understanding the discussion in this and following chapters.

2.2 Curriculum and Curriculum Reform

2.2.1 *Curriculum*

It is necessary to clarify some terms of curriculum and curriculum reforms by reviewing theory literature, therefore, to clear the follow-up frameworks of curriculum and evaluation. Tyler (1949) have discussed four fundamental questions about curriculum He refrains from directly addressing these questions, recognizing that the specific answers may vary depending on the school and educational stage. Instead, he aims to propose research methods and procedures for investigating these issues. According to his perspective, this approach embodies the fundamental principle of examining curriculum and teaching problems

What educational purposes should the school seek to attain?

What educational experienced can be provided that are likely to attain these

purposes?

How can these educational experiences be effectively organised?

How can we determine whether these purposes are being attained?

The four questions are regarded as the four steps or stages of curriculum development process: '*(1) clarification of purpose; (2) selection of learning experiences; (3) the organization of these experiences; and (4) the assessment of progress toward the attainment of the school's objectives.*'(Madaus & Stufflebeam, 1988, p. 200) The Taylor's principles of curriculum essentially elaborate on these steps further. Among them, clarifying objectives is the most crucial because all other steps revolve around it, which through *(1) the school's philosophy of education; (2) theories of learning; and (3) suggestions from subject matter specialists.* Therefore, no single source of information is sufficient to provide a basis for wise target selection. Due to the limited time and energy of school education, it is necessary to focus on a small number of very important targets. This requires filtering out numerous objectives that are not very important, contradictory, or unattainable for students.

Answering to these questions can be seen as exploring the structure or nature of the 'curriculum'. Answers should not be immutable but discussable. Kelly (2004, p. 4) clarified '*the total curriculum must be accorded prior consideration, and a major task that currently faces teachers and curriculum planners is to work out a basis on which some total scheme can be built*'. Stenhouse (1991, p. 4) defined curriculum as '*an attempt to communicate the essential principles and features of an educational proposal in such a form that it is open to critical scrutiny and capable of effective translation into practice'*.

Kliebard (1972) considered that the curriculum is likened to: 1) The means of production where the student is the raw material; 2) A greenhouse where students grow and; 3) A guided and companionable road over which students travel. The metaphor 'Processing' provides an industrial model where students are imagined as raw materials, which skilled craftsmen process into products according to strict regulations. The metaphor of 'growth' compares teachers to gardeners who have a clear understanding of the characteristics of various plants (students) and provide them with the necessary nutrients. The metaphor of 'tourism' likens teachers to tour guides, guiding students to appreciate various landscapes (knowledge, skills, abilities, and attitudes). What each tourist sees or finds interesting depends on their own background.

Young (2002) have suggested that '*a view of 'curriculum as fact' expresses many*

of the prevailing assumptions of educational practitioners, teachers and policy makers'. '*a view of the 'curriculum as practice' does not offer an adequate alternative to ideas about the curriculum defined in terms of the structures of knowledge'*.

Ellis (2014) considered the choice of regarding curriculum as 'prescription' or 'description', furthermore, in terms of focusing with intensions or experience. Kelly (2009) claimed '*the official or planned curriculum is meant what is laid down in syllabuses, prospectuses and so on; the actual or received curriculum is the reality of the pupils' experience*'. Curriculum practice ultimately closes the gap with the theory and curriculum studies must not lose sight of the relationship between the two sides of curriculum (Kelly, 2004; Stenhouse, 1975).

Generally, the curriculum can be considered as a comprehensive compilation encompassing objectives, content, implementation strategies, and evaluation procedures. It operates through levels and exerts influence on all stakeholders involved in the curriculum process, including policymakers, educators, and learners, by means of an ongoing feedback loop. Especially for a new curriculum, I consider figuring out the boundary of the levels of curriculum can be helpful for establishing the framework of this study. Therefore, I further discussed the levels of curriculum making.

2.2.2 *Levels of Curriculum Making*

Goodlad (1979) believed that curriculum inquiry should focus on at least three types of curriculum phenomena: 1) substantive, which refers to the common elements of all curricula, including goals, subject matter, and learning materials. Curriculum inquiry aims to reveal the essence and value of these phenomena. 2) political-social, which involves the political and social factors and their influence in the process of policymaking for curriculum objectives and methods. 3) technical-professional, which pertains to the professional and organizational factors with technical expertise involved in developing, improving or replacing curricula. They investigate and evaluate various benefits during the implementation of curriculum policies. Curriculum inquiry should be guided by anthropological logic or sociological logic, sometimes involving experimentation or design. To this end, he proposes a conceptual framework for understanding curriculum at different levels by dividing it into five levels and discussing three types of nature phenomena within these levels.

1. *Ideological curriculum*
2. *Formal curriculum*

3. *Perceived curriculum*
4. *Operational curriculum*
5. *Experienced curriculum*

Goodlad's model was seen as linear and as hierarchical, partly due to use of the term 'levels', and the positioning of the levels as institutional sites, rather than as forms of activity. Griffin (2014) presents Goodlad's three-level typology explicitly as institutional settings or actors: (1) societal – local and national boards of education, departments of education, federal agencies; (2) institutional – school faculties, central office, committees, etc.; and (3) instructional – teachers. Deng (2012) offers three levels for curriculum making: (1) societal (ideal or abstract); (2) programmatic (technical or official); and (3) classroom (enacted).

Another approach of curriculum making was developed by Priestley (2021) from the curriculum levels of Thijs and Van den Akker (2009). Priestley stated that *'instead these are forms of activity that operate in education systems as curriculum is made and remade in different settings; as sites of social activity with changing social actors, who are moving between sites, are being present in more than one, or actually becoming a site themselves depending on the social activity they are engaging in.'*(Priestley, 2021, p. 13)

Table 2.1

Sites of Curriculum Making (Priestley, 2021, p. 13)

Site of Activity	Examples of Activity	Examples of Actors
Supra	Transnational curricular discourse generation, policy borrowing and lending; policy learning	OECD; World Bank; UNESCO; EU
Macro	Development of curriculum policy frameworks; legislation to establish agencies and infrastructure	National governments, curriculum agencies
Meso	Production of guidance; leadership of and support for curriculum making; production of resources	National governments; curriculum agencies; district authorities; textbook publishers; curriculum brokers; subject-area counsellors
Micro	School-level curriculum making: programme design; lesson-planning	Principals; senior leaders; middle leaders; teachers
Nano	Curriculum making in	Teachers; students

	classrooms and other learning spaces: pedagogic interactions; curriculum events

The Three-level Curriculum

The intended curriculum includes the social and political circumstances, goals and missions, and teaching standards and content. The interpretation of curriculum designers' intention based on education theories and subject disciplines is particularly reflected in official curriculum documents.

The implemented curriculum includes teachers' teaching plan and practice in schools and classrooms. Teaches as the decisive implementers have profound influences on the delivery of the intended curriculum. These effects are reflected in teachers' belief, experiences, teaching practice and environment. In order to bridge the gap, local level, schools and principals are inevitably involved to the implementation and planning of this level curriculum. However, this may have negative effects on class teaching, as teachers may partially lose control over teaching content and students' behaviour.

The attained curriculum is mainly focus on what students attained from the implemented curriculum, which include students' outcomes, attitudes, and reflection on the schooling and curriculum.

2.2.3 *Curriculum reform*

According to Fullan (2016), there are three dimensions in educational changes for implementation: '*(1) the possible use of new or revised materials (instructional resources such as curriculum materials or technologies), (2) the possible use of new teaching approaches (i.e., new teaching strategies or activities), and (3) the possible alteration of beliefs (e.g., pedagogical assumptions and theories underlying particular new policies or programs)'*.

Fullan (2016) defined successful change as 'a process that shapes and reshapes good ideas as it builds capacity and ownership' and give six guidelines for recommendation.

1. Define closing the gap as the overarching goal.

2. Recognize that all successful strategies are socially based and action oriented—change by doing rather than change by elaborate planning.

3. Assume that lack of capacity is the initial problem and then work on it continuously.

4. Stay the course through continuity of good direction by leveraging leadership.

5. Build internal accountability linked to external accountability.

6. Establish conditions for the evolution of positive pressure. (Fullan, 2016, p. 63)

Hargreaves and Shirley (2009) proposed 'the fourth way of change' which is '*a way of inspiration and innovation, of responsibility and sustainability*' and '*brings together government policy, professional involvement, and public engagement around an inspiring social and educational vision of prosperity, opportunity, and creativity in a world of greater inclusiveness, security, and humanity*'.(Hargreaves & Shirley, 2009, p. 71) This way of change not only insists on the top-down national policy driven by standardization and macro targets, and also makes educators, parents, students and public engagement visible with 'six pillars of purpose and partnership'.

Apple (1993, 2013) believed that curriculum is the embodiment and symbol of the power, will, values, and ideology of the mainstream class. Curriculum knowledge is a kind of 'legalized' official knowledge. Curriculum reform is essentially political activities around official knowledge. Both policy and practice in the current education are the product of struggles and compromises among power groups, but such compromises are only temporary. Whenever there is an opportunity, all power groups in society will do their best to legitimize their own knowledge, protect their own social activity models, and enhance Their power in the social arena. The current curriculum policy and curriculum practice are the results of the temporary balance of power among various power groups.

Therefore, in this thesis, the curriculum reform represents a cumulative sum of purposeful changes in various stages of the new curriculum, including aspects such as curriculum policies, content, implementation plans, and evaluation.

2.2.4 ***Science curriculum reform in this study***

The framework of K-12 science education identified science curriculum undertaken using a set of 'eight scientific practices' and unified by a set of 'seven crosscutting concepts' (National Research Council et al., 2012). This model draws heavily on the competence-based approach to learning and assessment. As mentioned in the new curriculum standard issued in 2017, high school physics, biology, and chemistry courses are fundamental courses in the field of natural sciences for ordinary

high schools. They aim to implement the fundamental task of cultivating students' moral character and further enhance their core subject competencies. Additionally, they increase requirements for interdisciplinary practices, laying a foundation for students' lifelong development and promoting the inheritance of scientific endeavours and social progress (Moe, 2017). These curriculum standards are based on theories of curriculum reform and provide further elaboration on the content knowledge of each discipline.

On the contrary, Osborne (2018) argues that over the past 15 years, people have become increasingly aware of the diversity in scientific methods, epistemology, and ontology. This poses a challenge to the dominant view that science methods possess some form of unity. At the same time, Kind and Osborne (2017) propose six styles of scientific reasoning as a justification for science education, which *'provide a way to appreciate the intellectual and cultural contributions that sciences have made to contemporary thought'*.

Therefore, the technological rationality in traditional science curriculum and its reform is reflected in a curriculum methodology that values pragmatism, a reform and evaluation mechanism cantered on goals and efficiency pursuit, as well as a curriculum implementation organization structure and operation mechanism characterized by scientific layers. This is manifested in the emphasis on scientific knowledge, skills, and methods while neglecting human values. It also manifests in the adoration of curriculum objectives, policies, measures while overlooking the underlying cultural, political, and social factors behind ideas and concepts.

In this thesis, I hope to explore the essence and attributes of science curriculum theoretically, understanding it as a systematic and organized knowledge experience for learners. This includes both explicit and implicit aspects of science curriculum. In analysing specific objects, I focus on the composition of science curriculum in terms of subjects such as physics, chemistry, biology, and physical geography. Considering the inherent connection between mathematics, technology, and science, there may also be some coverage in analysis and application.

2.3 Context of Large-scale Curriculum Reform in China

Fullan (2009) reviewed the history and nature of large-scale reform in education system in the whole world. He observed that systematic tri-level (school/ district/ government) reform became more analytical as well as action-oriented. Although the

policies and strategies implemented in countries were widely divergent. He argued that future large-scale reform would be occurred beyond the education system as ‘a widening and deepening of system reform’.

Lawton (2012) answered the question ‘why change the curriculum’ from four aspects: historical, sociological, philosophical and psychological. Kelly (2004) argued that changes occurred in society have been social, moral and political as well as, indeed as a consequence of, technological and economic developments.

Mel (2021) reviewed the London and Manchester challenge programmes and stated a series of interconnected barriers for the implementation from social, political and cultural factors. Social factors include the extent to which relationships exist that encourage the sharing of expertise though mutual support and challenge; Political factors arise from the influence of the attitudes and preferences of key stakeholders; and Cultural factors are created by local traditions and the expectations of those involved as to what is possible.

To conduct an in-depth investigation into the reform of science curriculum in China, under the background of reviewing other reforms, this study aims to explain the development history and reform process of Chinese science curriculum from three perspectives. First of all, the political and policy development process at the national reform level. It is not only reflected in the social, economic, cultural and educational levels, but also leads the direction of the entire large-scale reform and determines the direction of development and the final outcome. The second is reviews of specific practices and evaluations up to the last large-scale curriculum reform, which includes specific aspects such as curriculum objectives, curriculum design, teaching plans, teacher evaluations, student evaluations, and standardized tests. Finally, combining the theoretical basis of this round of curriculum reform, it looks forward to the expectations and development prospects of China's large-scale curriculum reform.

To clarify these issues, following paragraphs explained the development and reform process of Chinese science curriculum from the political, economic, social and educational perspectives.

2.3.1 *Political Perspective*

Historically, Educational reform and even curriculum reform have been an integral part of social reform and policy reform, as the school education system is tasked with imparting knowledge, teaching skills, and shaping values and views of history. For a

long time, the education system has been used as a policy tool to solve social problems. Atkin and Black (2003) took an example that:

In the United States about 50 years ago, the schools were designated as the primary social institution for combating the country's most deep-rooted long-standing and serious domestic problem: race relations. (p.14)

Science education and curriculum play a relatively stable role in policy and social reform, because the development of science and technology is closely related to people's lives. When scientific knowledge is transformed into science curriculum and teaching, the public can intuitively see the positive effect of science education on personal progress and national development. Therefore, science curriculum reform can effectively demonstrate the effectiveness of national reform. However, since the main content of the reform of the early science curriculum was to update scientific knowledge and scientific methods, the science curriculum rarely carried ideological content, which led to the public agreeing with the importance of science education, but it was difficult to unify it from science education to understand the nature of science(Atkin & Black, 2003).

'Policy is, of course, even amongst politicians, a means rather than an end. In England and Wales, and no doubt many other countries, the ultimate ends so far as public policy is concerned, are only to a limited extent concerned with curricular and pedagogic change.'(Donnelly & Jenkins, 2001, p. 7)

'Over the last decade or so as nations in East and Southeast Asia find themselves at the top of a range of international measures of student achievement, of increasing interest is the role of the state in decisions over what counts as official knowledge and over what goes into the work of schools.'(2016, p. 4)

Under the context of Chinese curriculum development, whether it is the 'eight reforms' or 'five-stage reform' theory, the Third Plenary Session of the Eleventh Central Committee of China in 1978 is regarded as an important historical node (Jianjun, 2012; Zhang & Wan, 2017). The content of curriculum reform in this meeting has profoundly influenced the following at the same time, this is also a turning point in China's policy era. Before the Third Plenary Session of the Eleventh Central Committee, China was in a special era that emphasized class struggle and highlighted politics. Education should serve 'proletarian politics', and curriculum should also 'serve proletarian politics'. Therefore, to divide the historical stages of the basic education curriculum reform before the Third Plenary Session of the Eleventh Central Committee, the changes in the

political system and political situation at that time can be used as references. After the 'reform and opening up policy', education especially science education has received great attention from the whole society. The Chinese government has made a series of major decisions on education reform and curriculum reform, and promulgated relevant educational policies, regulations and curriculum policies. Therefore, in the third session of the Eleventh After the plenary session, the division of the historical stages of curriculum reform is based on major educational decisions and curriculum reform policies.

Role of Governments in large-scale reform

Fullan (2016) demonstrated that 'governments' have three positive effects on promoting continuous large-scale reform at national level: '*push accountability, provide incentives (pressure and support), and/or foster capacity building'*. If the government can implement policy with three effects, it can be the most valid and efficient way for curriculum reform. Hence, accountability has attracted attention of many governments. As the first comprehensive framework, No Child Left Behind (NCLB) policy boosts the integration of accountability, assessments and standards for large-scale reform in the United States. The integration of policy instruments is based on '*data-driven decision making (DDDM), the implementation of evidence-based practices, and increased school choice for parents'* (Datnow & Park, 2010, p. 209).

Datnow and Park (2010) reviewed implementation of large-scale educational reform at all levels of education system. They illustrate the 'co-construction' framework to examine the changes under DDDM and conclude:

Whereas a technical-rational view of educational change might suggest that implementation is an activity restricted to a group of people in schools at the bottom of the policy chain, we see here that implementation is a system-wide activity, even when the desired change is mainly at the school level. (Datnow & Park, 2010, p. 217)

However, governments face a dilemma promoting a large-scale educational reform. They have stress on solving problems quickly while they cannot control the changes at the school level. Fullan (2016) suggested that government should lead the reform with capacity building instead of accountability-driven to achieve sustainable development and innovation. China faced similar challenges during the fifth (1978-1981) and sixth (1983-1985) curriculum reforms, as the curriculum structure shifted back to subject-based courses and aimed to achieve educational modernization (Yuan & Liu, 2018). These time periods marked significant stages of change in government policies

regarding curriculum reform.

The Education Delegation visited China in 1977 and conducted on-site inspections of schools in Beijing, Shanghai, and other locations to learn about and discuss China's education development as it gradually recovered from the Cultural Revolution and returned to basics. After the visit, they discussed the relationship between China's politics and curriculum at the time.

First, symbols are utilized to present certain themes, messages, and desired behaviour patterns. Second, these symbols and themes provide a context for the presentation of more 'substantive' aspects of the learning process. Third, politics in its broadest sense enters the curriculum because of the connection of the classroom experience with the process of productive labour in its many different forms. Finally, politics is important in that it forms an integral component of the curriculum as a separate and distinct subject of study. (Anrig, 1979, p. 89)

Anrig(1979) believed that although the role of politics in education may gradually diminish, China's long-standing training tradition, the precedent of political education being upgraded during the Cultural Revolution, and the fact that an increasing number of families are accepting the inclusion of political education in the curriculum all indicate that Chinese education still has significant political components.

Apple and Lim (2016) also demonstrated the complex situation of politics in Asia.

For now, suffice it to say that while much of the politics in Asia remains in a state of transition – or more accurately, because of this – the process of curriculum reform in these places involves considerable ideological work with outcomes that can never be wholly captured by linear assessments of efficacy. (Lim & Apple, 2016, p. 4)

National Policy development in Chinese science curriculum

Through a review of the historical overview and policy texts of many scholars on China's curriculum reform, China's curriculum reform development can be divided into three major stages, corresponding to the time nodes of 1978 and 2000. In the three stages, the curriculum, textbooks, and policies in basic education have undergone various reforms, mainly reflected in the changes of tangible curriculum policy carriers such as curriculum plans (teaching plans), curriculum standards (teaching specifications), and textbooks, as well as the basic spirit of important resolutions, documents, and speeches of the Party and the state on curriculum reform. It shows that curriculum policy is constantly adapting and adjusting to social development conditions and political and economic needs, while reflecting the government's control and

influence over school curriculum. The policy issues of curriculum reform are often more continuous and inheritable, not solving one problem and completely eradicating it, then dealing with a completely new one. Any curriculum policy would leave its trace and become a subsequent problem that we must face(Scheffler, 1984). In this sense, policy reforms in curriculum often must confront past policy experiences in order to establish the current trajectory over time. The following attempts to understand and construct concepts about the current curriculum reform policies through the changes in time.

The first stage is the period of socialist construction before the reform and opening (1949-1976). In December 1949, at China's first national conference on education, the educational reform policy was established as 'building new democratic education based on the experience of old liberated areas and absorbing useful experiences from old education with the assistance of previous Soviet Union experiences.' The teaching theoretical system of 'teaching plans, 'syllabus,' and 'textbooks' from the former Soviet Union were introduced. By 1951, the first set of nationally standardized textbooks for primary and secondary schools was officially published. Education aimed to serve economic development while incorporating progressive ideas.

The curriculum changes taking place in Mao period have one common feature that all changes have been incredibly implemented in a highly efficient way because no matter curricula, teachers, and schools in Mao era have strong influence and close relation with politics and power of Mao. Following the tradition of Chinese culture and influenced by the social thought of his time, Mao emphasized the significance of education in creating a new social order. After embracing Marxism-Leninism, Mao continued to regard education as a powerful weapon to reach his political goals, asserting that 'to overthrow a political power, it is always necessary, first of all, to create public opinion, to do work in the ideological sphere'. In addition, Mao wrote in 1957: 'There is the struggle between the socialist road and the capitalist road… We must heighten our vigilance. We must conduct socialist education' (MAOTSETUNG, 1967, p. 350-387).

From the Great Leap Forward in industrial and agricultural production that emerged in 1958, the curriculum policy was also affected, and the curriculum reform entered the Great Leap Forward period. The primary and secondary school system was shortened, and more science courses were added to the secondary school curriculum. The production labour and physical labour subjects were opened to promote the

integration of curriculum and labour. The authority for educational management was decentralized, and localities were allowed to develop their own textbooks. The emphasis on the compilation of local textbooks can be considered a major leap forward in the reform of the curriculum textbook system. However, in 1961, the central government revised the fourth national standardized curriculum for a twelve-year school system, returning to the policy of unified management and requirements, and emphasizing the basics. The policy emphasized the fullness of basic knowledge and the strengthening of basic training, and appropriately reflected the new achievements of science and technology, and paid attention to aligning with the current teaching reality (Lv, 1999).

The Cultural Revolution period (1964-1976) was a time when our country's curriculum system and normal teaching order were seriously disrupted. The Central Committee's Decision on the Cultural Revolution required the reform of the old educational system, teaching principles, and methods, leading to a more thorough dismantling of the curriculum and textbook system established in the 1950s. Courses became revolutionary, political, and practical. With the outbreak of the Cultural Revolution, the development of primary and secondary school curricula was generally in a non-rational, chaotic state. On the one hand, curriculum management authority was decentralized, and the unified supply of textbooks for primary and secondary schools was abolished. The old textbooks were subjected to a thorough critique, emphasizing the class struggle consciousness and political colour of the curriculum and textbooks. On the other hand, the structure and content of the curriculum underwent dramatic changes, with only five courses: politics, Chinese, industrial and agricultural production knowledge, and military training. The study of basic knowledge and scientific theories was abolished, and the emphasis was placed on the practical effects of the curriculum, with a preference for industrial basis, agricultural basis, and political struggle, leading to a serious deterioration in science curriculum.

The second stage is from the period after the reform and opening up to the comprehensive development of compulsory education (1978-2000). In response to the new requirements of reform and opening up, it considered modernizing reforms in teaching content, adjusted teaching content and class hour structure according to the requirements of modern science and technology, and established two curriculum plans focusing on humanities and sciences.

The primary focus in China from 1978 is the economic reform and opening-up. As

economic development became the leading role of social life, it is necessary for education system be ready to support the ambition. Deng Xiaoping pointed out that the level of science and technology decide the limit of a country's economic development (Peng, 2005). Therefore, the first significant change in education is to impel basic education and higher education to attach great importance to cultivate talented people in science and technology. China began to regularise school curriculum and get rid of the thoughts of despising knowledge gained from the ten-year cultural evolution. As a milestone, the college entrance examination was officially resumed in 1977 to recreate the basic education system which closes to the intention of pre-cultural revolution format. Like Pepper's comment on post-Mao Chinese education that '…two steps forward, two steps back and begin again.' (Pepper, 1980, p. 1)

The Ministry of Education has issued a nationwide unified curriculum for full-time primary and secondary schools, restoring a subject-based curriculum structure and reintroducing cultural knowledge subjects. Music and art have been added as two new subjects, while agricultural basic knowledge has been removed and replaced with labour courses. The political course has been changed to an ethics and morality course. People's Education Press has restructured the fifth set of nationally standardized ten-year primary and secondary school textbooks, focusing on students' comprehensive development in terms of curriculum content. It not only emphasises the selection of fundamental knowledge but also considers students' intellectual development and skill cultivation. For example, it introduces some achievements in modern technological development and incorporates practical elements such as experimental demonstrations in science curriculum.

With the announcement of the 'Reform and Open Policy' in 1978, the Chinese government began to realize the importance of science and technology. Deng put forward the slogan of 'the primary productive force of science and technology', which is largely due to the huge changes brought about by the progress of science and technology in Western society. Therefore, the science curriculum reform is also carried out for this purpose.

Another milestone in curriculum reform is the compulsory education law from 1986. The People's Education Press has made efforts to compile the sixth set of nationally unified textbooks, which were put into use in 1982. This set of textbooks emphasizes the combination of ideology and science, focuses on the cultivation of basic knowledge and abilities, integrates traditional and modern scientific knowledge, and

emphasizes students' mastery of scientific learning methods. In addition, Shanghai, Zhejiang, and other regions served as experimental areas where locally compiled textbooks began to be incorporated into the mainstream. In 1986, the National Textbook Review Committee was established. These reform achievements laid a foundation for the curriculum reform after compulsory education. The 'Double Basics' task was proposed in 1992 and was further specified in 1994 as the 'Double Eighty-five' which means that by the end of the 20th century, nine-year compulsory education would be popularized in areas accounting for 85% of China's total population with a gross enrolment rate reaching 85% at junior high school level. During this period, a new round of curriculum textbook reform not only supported the implementation of compulsory education but also followed global trends in educational and curriculum reforms by absorbing international advanced experiences in various aspects such as curriculum objectives, content organization structure evaluation management etc., thus achieving modernization transformation in curriculum teaching. It can be said that it is a transcendence beyond Soviet-style curriculum system since New China was founded.' (Lv, 2008, p. 101)

However, implementation of the national curriculum must confront the large rural population issue which can be viewed as the issue of demand and supply. On the demand side, the compulsory education is a loss of rural parents' support because of the tuition fees, income expectation, and there is a common thought that a peasant's children can learn from their fathers instead of schools (Brown & Park, 2002).

Tu (2009) also criticise that this curriculum reform was unable to systematically respond to the problems encountered in the practice of curriculum reform. Firstly, the demand for curriculum reform policies came from the need for economic reform, in order to meet the demands of social transformation and public education resources. Therefore, the basic direction and ideas of the reform remained at a macro level without establishing a sound logic and rules for grassroots curriculum reforms. At the same time, there is a lack of empirical research in the field of curricula which makes it difficult to establish a complete and sustainable cycle for timely course reforms. As a result, although this curriculum reform was one of China's boldest policy changes since its establishment as a nation, government efforts towards promoting and implementing these reforms still appear quite immature.

The third stage is to establish a new curriculum system for quality education (2001-2016).

As a requirement of students' comprehensive capacities cultivation in 21st-century school education, quality education is raised and intend to cultivate students in all-round development of moral, intellectual, physical, aesthetics, and labour education. This means that children need more rest or spare time rather than knowledge learning in classroom, therefore, the first change in curriculum is to release children's burden in schools by simplifying school curriculum and decreasing time in classroom teaching.

The National Conference on Basic Education Work in 2001, 'Decision on the Reform and Development of Basic Education,' as well as the promulgation of the Ministry of Education's 'Outline for Curriculum Reform in Basic Education (Trial),' marked the comprehensive launch of the eighth round of curriculum reform in basic education since the founding of our country. This curriculum reform, underpinned by quality education, is a redesign and reconstruction based on previous seven rounds of curriculum reform. It makes statements regarding the goals and functions of curriculum reform, curriculum structure, curriculum standards, teaching process, textbook development and management, curriculum evaluation, curriculum management, teacher training and development etc., representing a comprehensive innovation involving fundamental concepts, basic systems and curricular frameworks.

The curriculum reform itself is a continuous process, with each reform reflecting the historical changes in the cultural content and essence of the curriculum. At the same time, it also alters the nature and direction of the curriculum history. The eighth curriculum reform is a special turning point in this process. It does not completely negate previous reforms nor declare an end to all past curriculum reforms. Instead, it represents an effort to systematically transform based on lessons learned from decades of experience in curriculum reform since the founding of our country. It is also a positive response to the overall situation and basic strategies of international and domestic education and social development.

Control of curriculum

Apple (2019) was trying to demonstrate the ideological nature of curriculum in the book 'Ideology and Curriculum' which has raised three challenged notions: '*1) that the selection processes are neutral; 2) that 'ability' is what schools actually do focus on; 3) whether the school are actually organized to teach technical curricular skills and information to all students so that each person has an equal chance at economic rewards*'

There are two requirements of ideological hegemony: 1) not only our daily lives

are saturated by ‘categories and structures’ created in economic circumstance; 2) these ‘categories and structures’ are legitimated by ‘intellectuals’ within ideological neutral packing (Apple, 2019). In Chinese curriculum background, to recognize Apple’s three notions, schools show weak power in selecting what knowledge and ability to teach while strong power appears in experts in university and government in terms of ministry of education. Besides, students have the least power in the education process though they should be the main character in curriculum.

In curriculum policies, especially in centrally controlled curriculum policies, the curriculum plans, standards, and textbooks are developed and issued by central authoritative departments. They serve as powerful means of controlling the curriculum. As reviewed and discussed in the last section on curriculum development since 1949, China has consistently adopted a centrally controlled curriculum policy, which is consistent with its long-standing highly centralized management model for curriculum administration. This model has two main characteristics (Zheng, 2005): firstly, local educational authorities and schools are not true decision-makers in terms of curriculum policies; they only serve as implementing units and play a role within the administrative chain. The content taught in schools, teaching load, textbook sources, and the standards that students need to meet are all determined by the centrally established curriculum policies. Secondly, the curriculum plans formulated by local educational authorities and schools are under the responsibility of government supervisory departments who act as the sole decision-making body and almost monopolize all decision-making power. In other words, local authorities and schools have virtually no say in terms of curriculum decisions.

Guo (2002) analysed the various conditions and motives that have led to the long-term emphasis on ‘control’ as the fundamental function of curriculum management in China and summarized them as follows: (1) It is a result of the centralized political structure at the central level. (2) It is related to traditional management culture in China. (3) It is a result of strengthening education's ‘social control function. (4) The institutionalization of curriculum also contributes to the trend towards ‘control’ in curriculum management. He also proposed that the focus of curriculum management should shift from control towards serving schools and teachers in curriculum development and implementation.

With the deepening of curriculum reform, as (Zheng, 2018) reviews the 40-year curriculum management system reform, before entering the third stage of curriculum

reform, a three-level curriculum management system suitable for the development of basic education courses has gradually formed.

The 'Curriculum Plan for Full-time Primary and Junior Secondary Schools with Nine-Year Compulsory Education' promulgated in 1992 stipulated the local curriculum, which is determined by local governments through unified curriculum plans and teaching outlines. The textbooks implement a 'single outline, multiple books' approach. In 1996, the 'Curriculum Plan for Full-time General Senior Secondary Schools (Experimental)' was issued, which specified that schools should reasonably set their own elective courses and activity classes. At the end of 1999, the National Third Conference on Education Work established a three-level curriculum management system of 'national curriculum, local curriculum, and school curriculum,' marking a significant shift in China's curriculum policy.

Yu (2004) summarized the policy texts on curriculum management and compiled the main responsibilities of the three-tiered curriculum administrative bodies into the following Table 2.2.

Table 2.2

The main responsibilities of the administrative subject in the three-level curriculum administration

Level	Main Responsibilities
National Level	Develop curriculum plans and national curriculum standards. Develop policies for textbook development, review, and selection, and organize the review and approval of textbooks based on the national curriculum standards. Develop guidelines for local and school-level curriculum management. Review and approve local curriculum development plans. Establish evaluation systems for basic education curriculum. Monitor the implementation of national curriculum policies and organize national level assessments. Revise curriculum documents according to the needs of educational reform and development.
Local Level	Develop a local curriculum implementation plan. Organize the review of school curriculum implementation plans and guide schools in the specific implementation of national or local curricula, the selection of textbooks, and the development of school-based curriculum. Develop local curricula. Provide services for the implementation and development of school curricula, helping schools solve educational problems. Monitor the implementation, evaluation, and examination of local curricula. Integrate social curriculum resources and guide various social forces to participate in curriculum development. Strengthen the management of textbooks, teaching aids, and other teaching materials Organize teacher training

School Level	Develop a school-based curriculum implementation plan. Select curriculum materials that have been reviewed and approved. Develop school-based curricula. Monitor the implementation of the curriculum plan, teaching, evaluation and examination, curriculum resource development and utilization. Establish a mechanism for school curriculum management involving teachers, students, parents, and community representatives. Organize in-house training. Provide services for teachers' teaching and students' learning.

The current curriculum management system in China has a distinct decentralization feature. Local governments and schools have gained certain autonomy in curriculum development, with schools having the freedom to choose their own teaching materials. The education sector encourages more internal and external stakeholders to participate in curriculum management and development. However, due to China's long-term implementation of centralized governance models through strong government-led development, there is a risk of being unable to create an environment that truly supports a decentralized curriculum management system, resulting in a bias towards ‘textual management’ over ‘problem-oriented management’. (Yu, 2004)

Furthermore, there is also an implicit management right in curriculum management, which is the right to evaluate courses. In China, this hidden curriculum management right is realized through the ‘gaokao’ (college entrance examination), avoiding the drawbacks of polarization in curriculum reform - the dilemma of either being too rigid or too chaotic. The path for truly decentralizing the rights of curriculum management still has a long way to go along with reforms in the gaokao system. (Long, 2012)

Therefore, China's curriculum control continued to be a factor influencing curriculum reform and implementation in the long term. Based on past experience, it is even more necessary to promote overall reform and establish appropriate supervision and evaluation mechanisms. These structural changes require both economic support and social support.

2.3.2 *Economic and social Perspectives*

Freire (2000) used bank savings as a metaphor for traditional school education, where education became a behaviour of students accepting the teacher's savings. The greater the ability to accept savings, the better the student was considered.

(a) the teacher teaches, and the students are taught;

(b) the teacher knows everything, and the students know nothing;

(c) the teacher thinks, and the students are thought about;

(d) the teacher talks, and the students listen—meekly;

(e) the teacher disciplines and the students are disciplined;

(f) the teacher chooses and enforces his choice, and the students comply;

(g) the teacher acts and the students have the illusion of acting through the action of the teacher;

(h) the teacher chooses the program content, and the students (who were not consulted) adapt to it;

(i) the teacher confuses the authority of knowledge with his or her own professional authority, which she and he sets in opposition to the freedom of the students;

(j) the teacher is the Subject of the learning process, while the pupils are mere objects. (Freire, 2000, p. 73)

Therefore, the viewpoint of curriculum design is that educators' role is to control the way in which this world enters students. The task of curriculum designers is to organize a process that fills students by storing information that constitutes true knowledge. However, the critical perspective demands questioning the authority of curriculum design experts and urges for a more democratic teacher-student relationship.

The researchers with a critical perspective on curriculum emphasize the theory of 'reproduction,' which refers to the social reproduction achieved through school curriculum. Apple stated that '*there can be no longer any doubt that schools do seem to be institutions of economic and cultural reproduction. However, the way this goes on within educational institutions is exceptionally complex.*'(2017, p. 1)

Bowles and Gintis (2011) point out that the main role of school education is not only the reproduction of labour division necessary for the continuation of capitalist society, but also the reproduction of bourgeois ideological consciousness and cultural values. They believe that a profound understanding of the function of school education can only be achieved through an awareness of its relationship with national politics and social relations. The different levels in education actually correspond to different levels in occupational structure. In their view, various social relationships in the classroom permeate schools in a subtle way, and influence students with authority concepts, social norms, and values. They also call for changes to be made to the social system and social relations upon which education relies for implementation.

Bourdieu (2000) believes that there is no direct relationship between education and politics or economics. Education primarily serves as a means of transmitting culture, and it only becomes an important social force through the medium of culture in social reproduction. He introduces the concepts of 'cultural capital,' 'cultural arbitraries,' and 'symbol violence.' He argues that the education system has its own cultural arbitraries, which are the dominant class's culture. In the process of education, this dominant class's cultural arbitraries are imposed on children from other cultures. The results are: (1) children from the dominant class continuously receive 'cultural capital' and find education easy to understand; (2) the dominant class's culture is portrayed as more advanced; (3) through hegemony curriculum, 'symbol violence' is imposed on children from other classes to achieve socialization.

Bourdieu's field theory and cultural reproduction (Bourdieu & Johnson, 1993) argue that education is primarily about transmitting culture, and through the medium of culture, it becomes an important force for social reproduction. Bourdieu points out that any culture relies on its own reproduction as a fundamental condition for its existence and maintenance. The significance of cultural reproduction lies not only in emphasizing the self-creative spirit and vitality of culture itself but also in highlighting the fluidity and cyclicality of its existence and development, demonstrating the dynamic nature of culture and its ability to renew itself. Symbolic practices of cultural reproduction continuously create and update the social world in which human life and action are embedded, determining the dualistic homogeneity structure of the social world.

When analysing Bourdieu's theory, Giroux(1983) believes that Bourdieu only sees the cultural nature of schools and the forms of knowledge as a weak reflection of ruling class cultural capital, but fails to see that this domination and control are manifested within the internal processes of school education through contradictions, conflicts, struggles, and resistance. Giroux argues that compared to simple reproduction theory, resistance theory is a more valuable and profound theory as it helps us understand the complex ways in which marginalized communities experience educational failure. However, he disagrees with Willis's assertion about anti-school culture, stating that Willis' characterization of criminal behaviour as the primary form of anti-school culture is not rigorous or hasty.

Giroux (1991) points out that 'critical pedagogy' is about respecting cultural differences and using a cultural critical perspective to create a new form of border pedagogy that transcends cultural boundaries. He believes that the margins are not an

abyss from which need to be rescued from cultural differences, but rather a place where these differences arise, and it is precisely these differences that shape us. Therefore, by using the concept of margins, it is challengeable all established authorities and question existing dominant cultures. In curriculum practice, students should become boundary crossers so they can understand cultural differences in their own terms and create a border zone. In this zone, different cultures can gain agency within existing power structures. In other words, teachers and students should engage with different cultures and discuss and transform them.。

The critical pedagogy has achieved an important transformation in contemporary curriculum research, shifting from curriculum making to curriculum understanding. This has led contemporary curriculum research into a new stage characterized by diverse research perspectives and varied discourse on curricula, which holds significant historical progress. However, some studies argue that using only the category of "resistance" to explain student behaviour is not comprehensive; the critical model simplifies all non-compliant student behaviours as ‘resistance’, which is an oversimplified approach (Hargreaves, 1982). For example, Woods (2012) once analysed eight different ways in which students react during school activities. This idealistic notion of curriculum tends to overlook practical issues such as curriculum development, implementation, and evaluation, lacking operability in practice.

2.3.3 *Educational Development*

Curriculum Implementation

Fullan and Pomfret (1977) summarized three approaches to implementing curriculum: mudding through, adaption, and fidelity. Similarly, Snyder(1992) considered research on curriculum implementation can be divided into three orientations: fidelity, mutual adaptation and curriculum enactment.

Fullan (2016) further summarised *“nine critical factors organized into three main categories relating to (A) the characteristic s of the innovation or change project (Need, Clarity, Complexity, Quality), (B) local context (District, Community, Principal, Teacher), and (C) external factors (Government and other agencies).*”

The implementation of a curriculum refers to the process of putting a new curriculum plan into practice. The new curriculum plan usually implies a transformation of the existing curriculum, and the implementation aims to achieve this transformation in practice, or in other words, to introduce the change into practice. For

many years, China's curriculum and textbooks have been basically unified nationwide. Curriculum planning, design, and evaluation are within the scope of responsibilities for educational administrative departments and subject experts, while curriculum implementation is the responsibility of schools and teachers. Despite extensive promotion efforts by relevant departments on new curricula and textbooks, there has always been a gap in understanding between decision-makers and implementers. In recent years, when carrying out curriculum reforms across provinces and cities in China, not only have they paid attention to listening to teachers' opinions but also provided opportunities for teachers to participate in curriculum design as much as possible, which can be seen as a good attempt.

Curriculum implementation and teaching

Regarding the question of how to perceive the relationship between curriculum and teaching, the three metaphors raised by Saylor et al (1981) proposed can assist in contemplating and examining the essence of this issue."

Metaphor 1: The curriculum is like a blueprint for a building; teaching is the actual construction process.

Metaphor 2: The curriculum is like a game plan for a match, which is developed by coaches and players before the game; teaching is the process of playing the match.

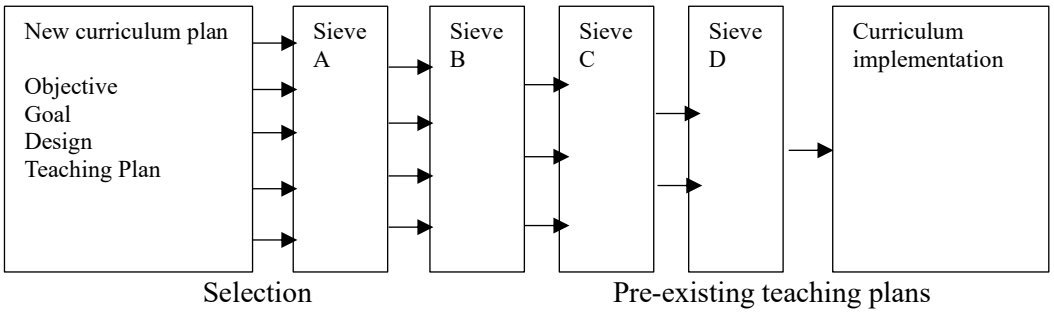
Metaphor 3: The curriculum can be seen as sheet music; teaching is the performance of the piece.

These three metaphors not only involve the relationship between curriculum and teaching, but also touch upon the question of what teaching is. In fact, metaphor one implies that 'teaching is a science'; metaphors two and three imply that 'teaching is an art'.

Any curriculum design can only be completed through specific teaching work. If paying attention to the various factors that teachers consider when preparing lessons, there have been a more intuitive understanding of curriculum implementation. Saylor et al (1981) used the following diagram to illustrate the steps that teachers go through when preparing lesson plans.

Figure 2.1

Teachers as Decision Makers in Curriculum Implementation



A. The values and expectations of the local community
B. The needs, interests, abilities, and roles of students
C. The educational environment - classroom organization, curriculum, support or limitations from administrators
D. The ultimate decision of the teacher on when to dim the lights

This model assumes that teachers' teaching is based on a new curriculum plan. Teachers' values, knowledge, and skills influence their choices in every instance. Teachers consider the goals, content, and organization of the curriculum and imagine a range of possible teaching plans to implement the curriculum plan. These potential teaching plans need to go through layers of 'screening', checking if they align with community values and educational expectations; if they can be accepted by specific students; and if they have appropriate conditions. And these decisions are related to teachers' qualities and experiences. Therefore, it can be inferred that certain parts of the curriculum plan have never been truly implemented.

From this, an effective curriculum plan is a necessary condition for good classroom teaching, but not a sufficient one. This is because an effective curriculum plan cannot guarantee good results. In fact, two teachers implementing the same curriculum plan may achieve different outcomes. The effectiveness of teaching is influenced by both what is taught (the curriculum) and how it is taught (teaching methods). The conditions of teaching play a restrictive role in the success or failure of the curriculum plan. Now let's analyse the issues with teaching.

Process model and the Teacher as Researcher

Stenhouse (1991) viewed curriculum as an attempt to translate educational theories into practice is an ongoing process of development and refinement. The process-oriented curriculum design method aligns with this spirit. In fact, the process-oriented approach aims to address the fundamental issues in curriculum design - content

selection, instructional processes, and evaluation - not by breaking down general educational objectives into specific goals. Instead, it directly focuses on continuously adjustment of the educational process to maximize its effectiveness and facilitate optimal learning and development for students.

Stenhouse introduced the concept of "principles of procedure" from Peters (2015), believing that the various values that truly guide teachers in their educational activities are reflected in the educational process itself, rather than in the desired outcomes. Therefore, specifying detailed goals for teachers does not help them choose and create appropriate teaching strategies. This requires the implementation of principles of procedure. Curriculum development should first reach a consensus on these principles. By clarifying the principles of procedure that valuable educational activities should include, teachers can continuously reflect on these principles and their underlying values during their engagement in educational activities, thereby developing understanding and judgment abilities towards the teaching process.

Furthermore, Stenhouse is committed to expanding teachers' professional autonomy in order to effectively promote understanding of the teaching profession and improve professional practice. This has sparked a movement of "teachers as researchers," encouraging teachers to integrate teaching with educational research.

Each classroom should not be an island. Teachers working in such a tradition need to communicate with one another. They should report their work. Thus, a common vocabulary of concepts and a syntax of theory need to be developed. Where that language proves inadequate, teachers would need to propose new concepts and new theory. (Stenhouse, 1991, p. 157)

Although Stenhouse's process model is largely based on his views on the purpose of education, the nature of knowledge, and its value, objectively speaking, his construction of the process model is much inferior to his criticism of the goal model. Despite proposing good ideas for curriculum planning, his discourse on the process model remains based on personal experience and lacks specific instructions for action or a systematic summary in theory. As a result, it has not had much impact in curriculum practice. Frankly speaking, 'the teacher as researcher' is a great proposition and an ideal pursued by educational workers. However, under current conditions, this is a difficult ideal to achieve.

Practical curriculum paradigm

Schwab (1969) believes that the traditional development model focuses on

students' ultimate learning goals, emphasizing purpose, outcomes, and behaviour control. It controls the entire process of curriculum development, implementation, and evaluation through pre-established behavioural objectives. The curriculum value it embodies naturally pursues technical interests. In contrast, the practical curriculum development model views the curriculum as an interactive and organic "ecosystem", based on a consistent interpretation of its significance. Through mutual understanding and interaction among the elements of this "ecosystem", it promotes students' interest, needs satisfaction, and improvement in abilities and virtues. Therefore, it focuses on the process of curriculum practice itself (including teachers' teaching and students' learning), emphasizing means, processes, mutual understanding, and interaction. Without a doubt, its embodiment of curriculum value lies in practical interests rather than technical interests.

The focus of Schwab's argument is to illustrate that traditional curriculum inquiry is "theoretical," while the curriculum inquiry he advocates for is "practical." In his view, theory and practice are fundamentally different in terms of purpose or outcome, research subjects, sources of problems, and methods.

In the paradigm of practical course research, courses cannot be developed without the involvement of teachers and students. Teachers and students are the legitimate subjects and creators of the curriculum, together with subject content and environment forming the four elements of a curriculum (1973). Among them, teachers are the main designers of school curricula. They can moderately add or delete, flexibly adjust and process course content during implementation according to actual educational contexts, showcasing their creativity to better adapt to students' learning situations. Students are also important subjects and creators of school curricula. Although they cannot directly design or develop courses, they have the right to choose from the courses provided by teachers and question how valuable certain learning contents are as well as how to complete these learning processes, demanding answers from teachers. Through these means, all aspects of students' life experiences can be involved in the process of curriculum transformation.

In Schwaab's view (1973), the ultimate goal of curriculum practice inquiry is to bring about a transformation in the curriculum decision-making system. Specifically, he advocates for a shift from the top-down approach to curriculum decision-making to an approach that is bottom-up. The foundation of decision-making lies at the local level rather than at the central level. According to Schwaab, the former represents a

bureaucratic system while the latter represents a democratic system. However, the "bottom-up" collective deliberation approach advocated by the Curriculum Research Institute provides opportunities and venues for teachers, students, parents, and community representatives to express their own views. However, due to different backgrounds of individuals involved, it is difficult to reach a consensus on curriculum issues.

School-based Curriculum in China

The most significant change in curriculum during quality education reform (from 2001) is to start exploring and developing school-based curriculum in China. The official document issued by minister of education in 2001 demonstrated that besides implementation of national curriculum, local schools are encouraged to develop specific school-based curriculum adapting to local regional circumstance. This indicates that school-based curriculum is officially involved into national curriculum to provide opportunities for schools and teachers to design their own curriculum.

In nearly 20 years practice in China, schools-based curricula have already rooted and sprouted, however, there are still some misconceptions with school-based curriculum (Gu, 2004a). For example, some schools view developing school-based curriculum simply equivalent to textbooks, teacher-based teaching or extracurricular activity. As an integrated part of the national curriculum, school-based should not be attached to examination but an individual curriculum reflecting teachers' and schools' thinking and students' demand with local social, cultural, and economic characteristics. The initial educational goal of quality education is not only to cultivate well-developed individuals, but also to establish a flexible educational and curricula system in China.

School-based curriculum plays a crucial role in the new curriculum because of the changes on assessment for students in basic education. The new assessment tends to evaluate students in a comprehensive way not only focus on the scores of school subjects (Gu, 2004b). Chinese school-based curriculum should focus on the flexibility of its curriculum plan and the diversity and breadth of curriculum activities. The flexibility of the curriculum plan reflects both the societal demand for adaptability and the inherent diversity in students' development within schools. This is manifested by: 1) respecting students' interests and incorporating diversity and hierarchy into curriculum objectives; 2) providing flexible options for students to choose from in terms of curriculum content and standards; 3) emphasizing a combination of overall promotion and individualized guidance through layered classification in the process and

methods of implementing the curriculum (Gu, 2002).

On the other hand, the breadth and diversity of curriculum activities refer to creating various spaces for students' activities, including social, technological, productive, literary, artistic, sports-related activities both inside and outside school. This allows students to autonomously select activities across multiple fields to explore their potential, determine their developmental direction gradually while showcasing their abilities. Ultimately, this approach fully shapes and demonstrates their subjectivity and individuality.

2.3.4 *Summary*

The above content reviews the three stages of China's large-scale curriculum reform, which have been formed and implemented after inheriting, developing, accumulating, and discarding various policy orientations to adapt to the needs of the times and promote education towards more comprehensive development and personalized cultivation. Subsequently, several important models and paradigms of curriculum theory research are briefly described, which can help understand the development context of curriculum research and attempt to construct a theoretical curriculum model for China. Next, I focused on the main object of this study - curriculum reform based on core competencies.

2.4 Curriculum Reform based on Core Competencies

2.4.1 *Core Competencies*

To truly integrate the concept of core competencies into curriculum, assessment, and educational practices, countries around the world have conducted corresponding theoretical, policy, and practical research on the connotation and structural framework of core competencies during the implementation of national curriculum and educational goals. As a result, different conceptual expressions have been proposed as research outcomes by organizations such as OECD, EU, UNESCO, and Australia referring to them as 'key competencies', while countries like UK, France, Germany refer to them as 'key skills', 'core skills' or 'basic skills'. The United States refers to them as '21st century skills' or 'core skills', New Zealand calls them 'key competence essential skills', and South Korea refers to them as both 'key competencies' and 'critical competencies'. There are various ways in which the concept of core competencies is expressed worldwide.

Corresponding to these various expressions internationally and considering that this study focuses on China's curriculum reform, this article adopts Lin's terminology using ‘Core Competencies’ for consistency.

After synthesizing research from other countries and organizations, Lin (2016) defines ‘core competencies’ in the context of China as ‘essential qualities and key abilities that students gradually develop during their education process to adapt to personal lifelong development and societal needs.’ Similarly, TSAI (2018b) defines ‘core competencies’ as ‘*integrated knowledge, skills, and attitudes that actively respond to individual and societal life demands, enabling individuals to lead successful and responsible social lives while facing present and future challenges.*’ Core competencies are a combination of various requirements for students' knowledge, skills, feelings, attitudes, values. It focuses on the process and emphasizes students' understanding during their cultivation rather than being outcome oriented. At the same time, core competencies possess stability along with openness and developmental potential. They are a dynamic optimization process accompanying lifelong sustainable development that adapts individuals to future society for promoting lifelong learning and achieving comprehensive development. Core competencies not only promote individual development but also contribute to forming a well-functioning society.

The theme of 'core competencies' has become a common concern in many countries and regions, with schools being encouraged to cultivate 'core competencies' through education. This is a curriculum reform issue that has received high attention from international organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Organization for Economic Cooperation and Development (OECD), and the European Union (EU). For example, in 2003, the Education Research Institute of UNESCO proposed five core competencies, advocating that modern individuals must possess lifelong learning skills to adapt to the ever-changing society. These core competencies include ‘learning to know,’ ‘learning to do,’ ‘learning to live together,’ ‘learning to be,’ and ‘learning to change.’ (Gordon et al., 2009)

Next, I would focus on the international experience of national curriculum reform based on core competencies, and finally elaborate on China's core competencies model and research orientation

2.4.2 *Experiences of core competency reform*

The stones from other mountains can be used to polish jade (The Books of Songs, 2000). Studying China's curriculum framework based on core competencies requires looking beyond the educational jungle to the pioneers. Nations and various international educational organizations are working to address the question of what type of individuals should be nurtured to confront the challenges of the new century and are striving to formulate a curriculum framework centred on core competencies.

In 2006, the European Parliament and the Council formally adopted the Recommendation on Key Competences for Lifelong Learning, which encompasses communication in the mother tongue, communication in a foreign language, mathematical competence and basic competence in science and technology, digital competence, learning to learn, social and civic competences, sense of initiative and entrepreneurship, cultural awareness and expression. These eight core competencies are interconnected and mutually reinforcing: language fluency, literacy skills, mathematics acumen as well as information and communication technology form essential foundational knowledge of learning. The ability to learn how to learn underpins all educational endeavours. Moreover critical thinking abilities creativity initiative problem-solving capabilities risk assessment decision-making skills emotional regulation permeate throughout the specific content of the eight core competencies. (EC, 2006)

Since its adoption, the Reference Framework has led to varied reforms in Member States. Progress has been made in key competencies closely related to traditional school ‘subjects’ such as language and foreign language communication skills and mathematical ability, while progress has been slower in competencies that transcend traditional subject boundaries, such as learning to learn, entrepreneurial ability, and social and civic competencies. (EC, 2018)

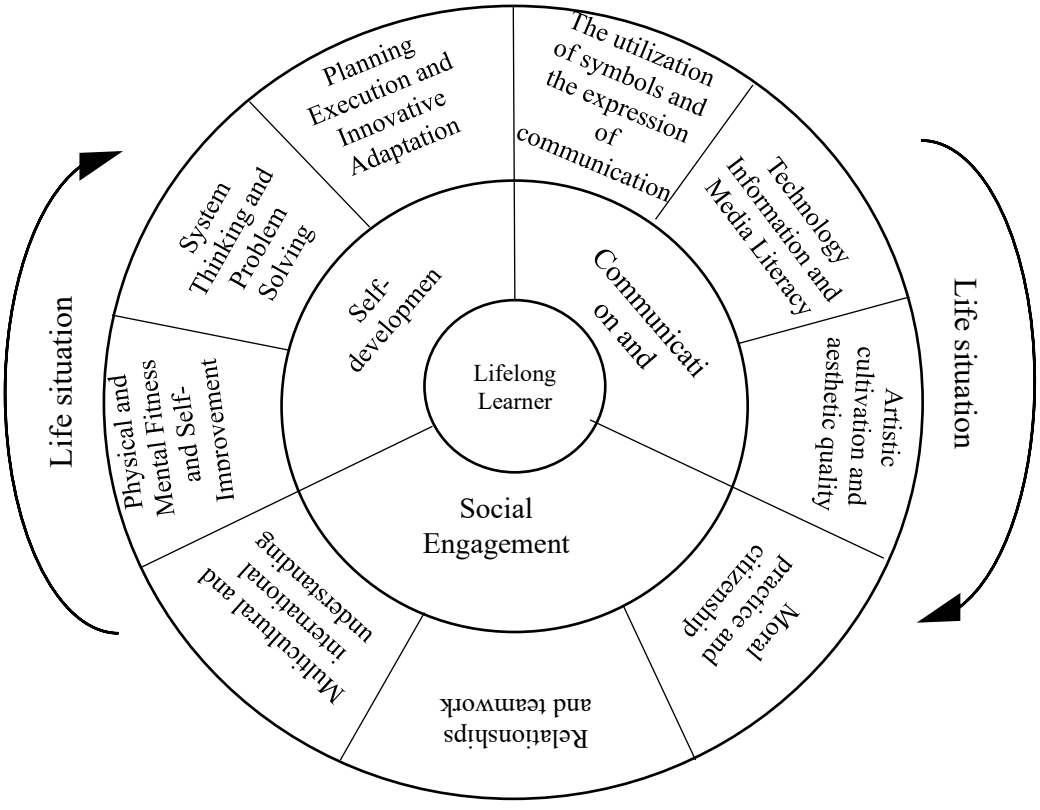
In 2014, Chinese Ministry of Education promulgated the ‘Opinions on Deepening Course Reform and Fulfilling the Fundamental Task of Moral Education and Personality Cultivation’, placing ‘core competencies’ in deepening curriculum reform to implement the educational goals of moral education and personality cultivation (MoE, 2014). This is the first time that the term ‘core competencies’ appeared in China mainland’s official archives. After studying the core competencies framework of various countries and regions and drawing on the Chinese interpretation and

localisation of the concept of core competencies in Taiwan, Lin (2016) released the overall framework of Chinese Students' Development of Core Competencies.

The education authorities in Taiwan passed the 'Development Guidelines for the 12-Year Basic Education Curriculum' in 2013, and subsequently released the 'General Principles of the 12-Year Basic Education Curriculum Framework', which requires all schools to implement the three core competencies of autonomous action, communication and interaction, and social participation, and to specifically translate them into nine major projects: A1, physical and mental fitness and self-improvement; A2, system thinking and problem-solving; A3, planning execution and innovative adaptation; B1, the utilization of symbols and the expression of communication; B2, technology information and media literacy; B3, artistic cultivation and aesthetic quality; C1, moral practice and citizenship; C2, relationships and teamwork; and C3, multicultural and international understanding as the core for curriculum integration, which not only emphasizes personal responsibility and knowledge, skills, and attitudes, but also covers citizenship rights and responsibilities, and places greater emphasis on moving from individual autonomous action to communication and interaction between individuals to relationships between individuals and groups in society, and on raising

Figure 2.2

Core competencies of the rolling wheel image (TSAI, 2018a)



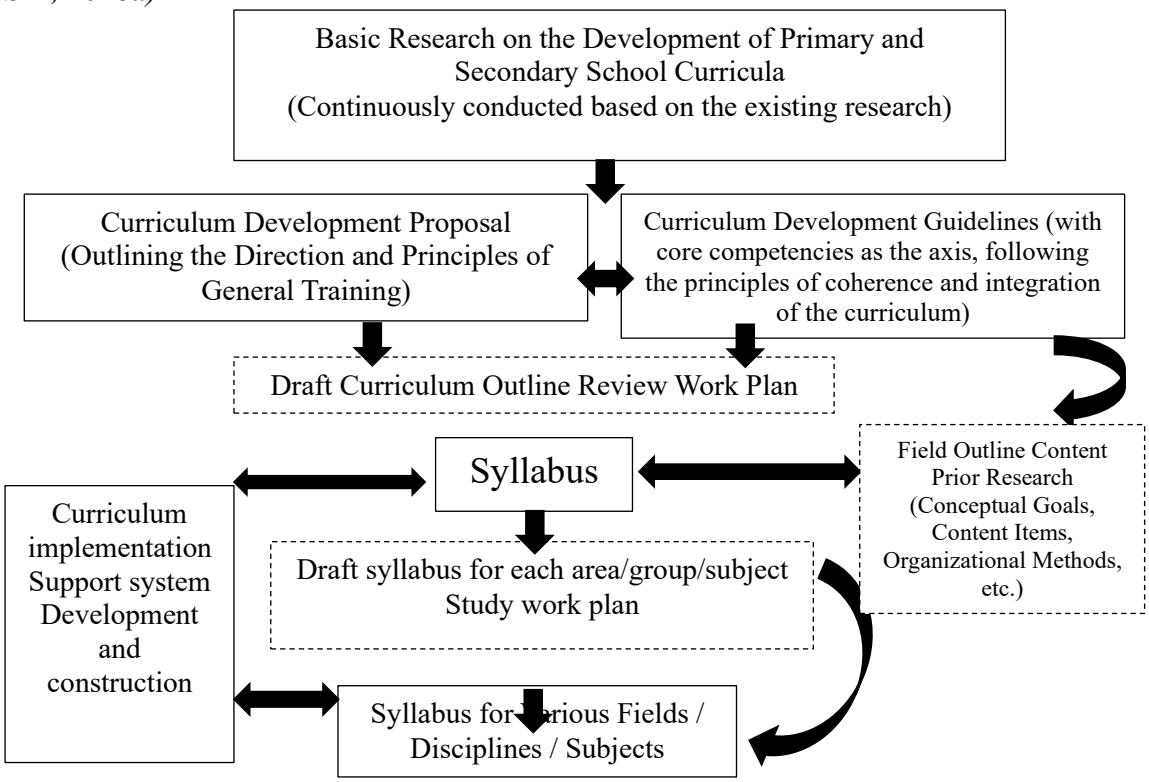
the spiritual values of human civilization (Figure 2.2).

Tsai joined Lin's research team to share Taiwan's experience in core competency-based reform. Based on the Taiwanese experience, Lin (2016) believed that mainland China's curriculum reform also needs to be based on a new curriculum system that emphasises core competencies to cultivate students' core competencies for the future society. A specific introduction to China's core competency indicators system is presented in section 2.4.3.

The 12-year compulsory education curriculum reform in Taiwan integrates vertically and integrates the courses from elementary school to senior high school, *solving the problem of disconnection between primary and secondary school courses and vocational high school courses* in the past. According to core competencies, learning is divided into educational stages, fields, and cross-field / subject areas, and each field / subject area can be transformed into field / subject core competencies and field / subject learning emphasis based on its own characteristics, philosophy, and goals. This type of core competency-based curriculum reform adds core competency-based curriculum design on top of field / subject curriculum, emphasizing curriculum, teaching, and assessment that are guided by core competencies. (TSAI, 2018a).

Figure 2.3

The Development Framework for the 12-Year Basic Education Curriculum (TSAI, 2018a)

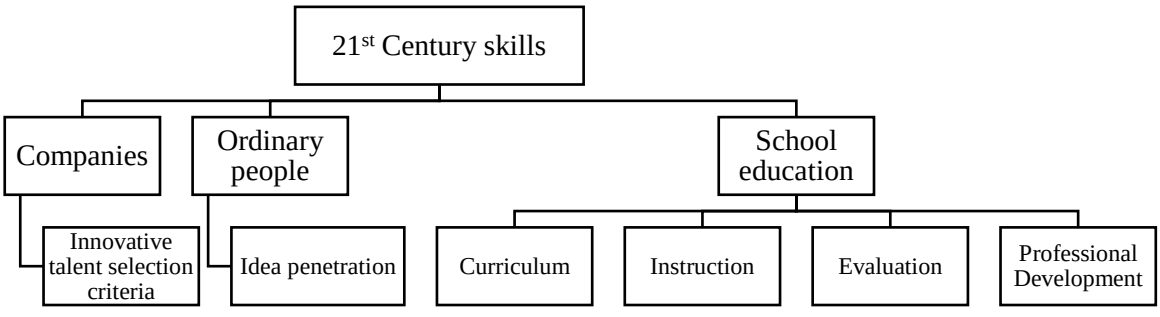


Lin (2016) believed that the research on the core competency system is a relatively macroscopic study, mainly focusing on the overall picture of the key competencies that students can ultimately achieve after going through the educational process in different educational stages. Based on completing the framework of the core competencies system, determining the core competencies and its performance characteristics of each educational stage based on the general framework, and doing a good job in the vertical connection of core competencies in different educational stages from the perspective of student development is an important link for the ultimate implementation of core competencies. This vertical connection can achieve the purpose of vertically penetrating the general framework of the core competencies system in each educational stage and building a bridge for the organic combination of core competencies and various subject curriculum.

The United States, in collaboration with the Organization for Economic Co-operation and Development (OECD), conducted research on defining and selecting competencies, and identified seven core competencies. Following this, in response to the belief that the current educational system is not adequately preparing the next generation of talent for the 21st century, the Partnership for 21st Century Skills (P21) published the '21st Century Skills, Education, and Competitiveness' in 2008, outlining a technical framework for cultivating 21st century talent. (Trilling & Fadel, 2009)

Figure 2.4

Basic Framework for the implementation of P21 (Lin, 2016)



Partnership for 21st Century Skills in the United States has been pursuing three parallel strategies to collectively advance the implementation of 21st Century Skills (Figure 2.4): fostering collaboration with businesses, effectively mobilizing their

support, and conducting comprehensive surveys on current talent core competencies for the purpose of selecting and refining 21st Century Skills. Additionally, updating the selection criteria for talent acquisition and human resource management objectives is aimed at promoting the widespread application of 21st Century Skills within society. Furthermore, national surveys are being conducted along with launching nationwide dialogues to meticulously select and refine 21st Century Skills. Lastly, diverse communication channels such as radio broadcasts, magazines, and videos are being utilized to disseminate information about 21st Century Skills to update public perceptions regarding talents and create a conducive social environment that fosters progress in integrating these skills into school education. (Lin, 2016)

After the establishment of the core competency system, inspired by the P21 framework of the United States, Lin (2016) proposed to attach importance to the transformative role of teachers in school education. Incorporate the relevant contents of core competency into the process of teacher training and professional development guidance to help teachers integrate core competency into actual teaching and ultimately achieve the common development of core competency for both teachers and students. At the same time, in the advancement process of curriculum, teaching, evaluation, and teacher professional development based on core competency, it is also necessary to construct a systematic core competency cultivation environment at different educational levels and fields through various approaches. Publicize core competency through various educational mechanisms such as family education, social learning, and lifelong learning to provide favourable social environmental conditions for the implementation and promotion of students' core competency in school education.

2.4.3 *China's curriculum reform theory and research based on core competencies*

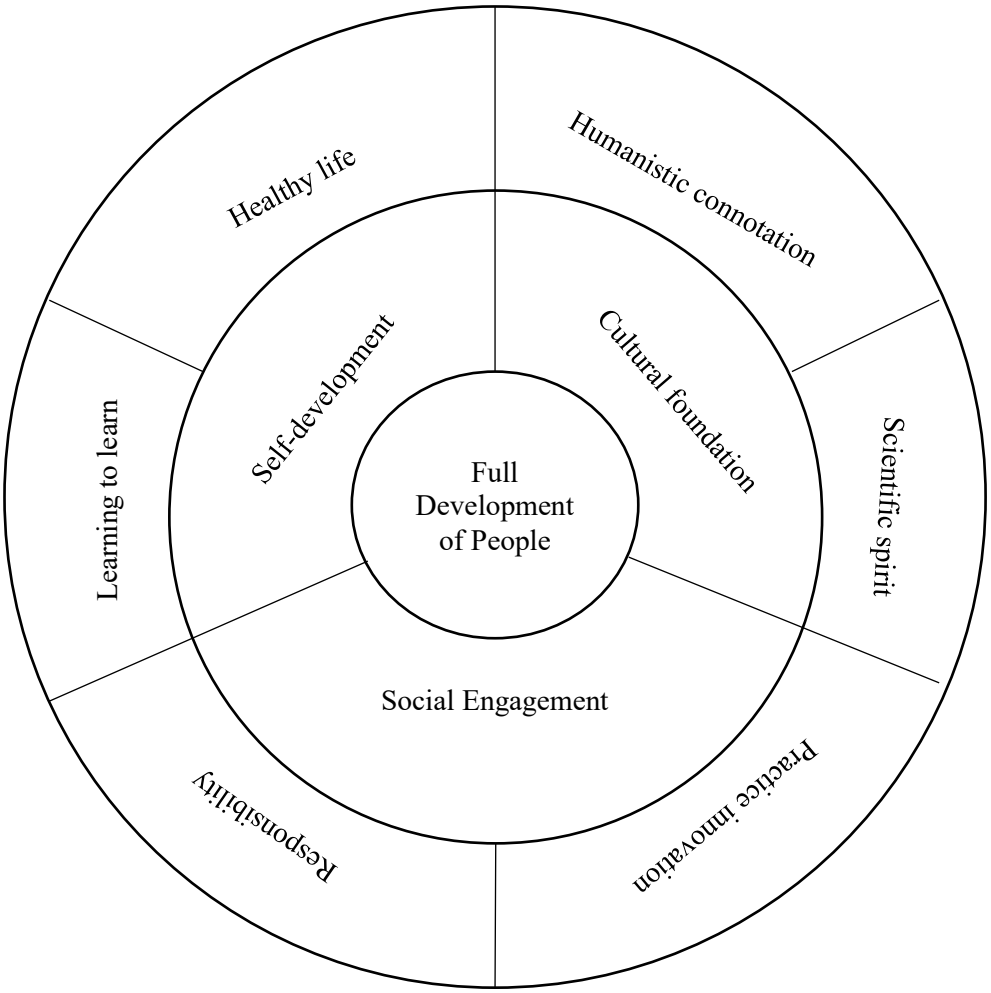
The ‘all-round’ education for quality did not achieve its initial goals because the examination-oriented study is still the stream of basic education, especially in high school education. This can be seen as experimental period for the three-dimension objectives from 2001, which the third stage of China’s curriculum development. (Xia & You, 2023) ‘Quality’ was raised coinciding with education and namely opposite to the examination-oriented curriculum and pedagogical circumstance (Lin, 2016). It may not suit for the aim of cultivating 21st-century individuals with international capacities. Therefore, as an extended concept from quality, ‘competence’ indicates a more synthetical representation of knowledge, capacity, and attitude (Lin, 2016).

Competence is a complex concept which corresponds to students or learners, which opposite to the subject-oriented curriculum and pedagogy.

According to the synthetical and generalised review of the frameworks of five international organisations and 24 countries and regions, comparison study is conducted to support the 21st-century competence education and curriculum. (Shi, Liu, Liu, Zhou, Chen, Liu, & Wei, 2016)

Figure 2.5

Core competencies for developing 21st century young generation



(Research Group of the core competences for Chinese students' development, 2016)

Table 2.3

Basic contents of Chinese student development key competences

Core Competences		Basic Contents
Cultural foundation	Humanistic connotation	Humanistic accumulation
		Humanistic feelings
		Aesthetic taste

Core Competences		Basic Contents
	Scientific spirit	Rational thinking
		Criticize and challenge
		Dare to explore
Self-development	Learning to learn	Love to Learn and Be Good at Learning
		Frequently reflection
		Information awareness
	Healthy life	Respecting life
		Healthy personality
		Self-management
Social engagement	Responsibility	Social responsibility
		National identity
		International understanding
	Practice innovation	Labor consciousness
		Problem solution
		Technology application

(Core Competencies Research Group, 2016)
Detailed information is in Appendix 9: Basic contents and main features of Chinese student development key competences

In addition, examples of official documents or research reports from various countries and regions could illustrate the ideas and understanding about how 21st Century Competencies could be incorporated into current educational system (LIU, WEI, ZHOU, SHI, WANG, LIU, Tan, & LIU, 2016).The national curriculum in China needs to integrate with the framework of 21st Century Competencies with both international and local perspectives. At the same time, some interdisciplinary themes like STEM need to be embodied in several subjects to help students experiencing the real world in a more general way.

2.4.4 *Core competency reform in China*

In China, there is a primary and authoritative database which is called China National Knowledge Infrastructure (CNKI), including almost every academic article written in Chinese. An advantage of using the databases is that the electronic keyword readily reviews title, abstract, keywords and even whole text of a study.

The original search utilized the following keyword is Core Competence.

Inclusion criteria for study review.

A study was included if it was:

1. Relevant to science curriculum reform;

2. Journal article listed in this study should be published in a core journal;

3. Printed in Chinese. (This study focused on Chinese science so that Chinese

researchers could be the most suitable target group. It is undeniable that some relevant studies are published in English. However, most of them have Chinese version included in CNKI);

4. Published between 2017 and 2022;

5. Had a national distribution in China;

6. Served as a record of research activity in secondary education, and

7. Served as a prominent journal in the field of secondary education.

Exclusion criteria.

1. Educational research includes many journal articles. Some of them could not be easily accessible. As a resource listed in systemic research, the research needed to get the full article instead of only the title and abstract. That literature which I could not get the full content would be excluded.

2. In inclusion criteria, it has mentioned this study focuses on science curriculum reform. That literature which does not mention their subject would be excluded.

3. Core competence is the central theme of this study the literature whose core topic is not core competence would be excluded.

CNKI database search strategy

Electronic databases provide the admission of viewing an inclusive collection of literature published in Core Journals, CSSCI. I completed the database search fields using the keywords listed earlier and their combinations and as a single statement with Boolean operators (e.g., SU = ‘core competence’). To narrow the search results, this research utilised two limiters, located below the main search fields. The first limiter, ‘Discipline’, restricted results to the scope of ‘Social Science II', and the second limiter, ‘period’, listed January 1, 2017, to Dec 31, 2023. For journal article searching, the study utilised another limiter, ‘source categories’, literature published in Core Journals.

Expert searching relies on search strategy that constructs by search item, expression, and Boolean operators. CNKI expert searching includes 17 search items. This study chooses ‘SU', which means ‘Subject' limiting the searching grid to the title, abstract, and keyword. Considering the aim of this study, search strategy would be: (SU = ‘core competence’) AND (SU= ‘physics’+ ‘science’+ ‘chemistry’+ ‘biology’- ‘English’- ‘Chinese’- ‘history’- ‘politics’- ‘music’- ‘geography’). This search strategy means that literature’s title, abstract and keyword should include keywords: ‘core competence’, while include ‘physics’ or ‘science’ or ‘chemistry’ or ‘biology’, but not include ‘English’, ‘Chinese’, ‘history’, ‘politic’, ‘music’ and ‘geography’. This expert

search is limited in sub-discipline ‘Secondary Education’ of ‘Social Science II’. There were only 179 items that could meet the searching criteria. Studies that met all inclusion criteria of electronic search underwent a second screening that included a reading of the title, purpose, abstract of each study. Next round of more detailed analysis led to a selection of literature, which meets the final criteria. 64 papers had been identified as studying core competence in high school.

Table 2.4

Aim of study distribution in core journal articles

Aim of study		Frequency	Percentage (%)
Valid	About teaching	23	36.9
	About textbook	11	16.9
	Development Study	22	33.8
	About evaluation	8	12.3
	Total	64	100.0

The distribution of research aim in core journal articles is 23 About teaching, 11 About textbook, 22 Development Study and 8 About evaluation. About teaching research refers to investigate effective methods for delivering core competences in teaching. About teaching research aims to investigate strategies for incorporating core competencies into textbooks. Development Study is the interpretation of the core quality in the curriculum standard. About evaluation aims to investigate methods for evaluating the core competences of students.

In the solution of real-life problem, integrating knowledge, methods, applications cultivate students' problem awareness and innovative thinking, gradually internalizing and expressing the core competencies of the chemistry discipline (Shi, Li, Guo, & Tian, 2022). In the classroom, students' scientific inquiry, scientific thinking, and scientific attitude and responsibility are cultivated through the creation of experiential inquiry scenarios, open activity scenarios, insightful problem scenarios, and perceptual story scenarios (Liu & Deng, 2020). Dong (2020) attempt to design a unit of instruction. Using the general concept of biology to construct the main framework of biology curriculum content, the teaching process should focus on practice and pay attention to the practical experience of students' learning process, developing students' core competencies in the biology discipline (Zhang & Lv, 2019). Hao and Fan (2019) proposes focusing on important concepts, paying attention to concept understanding, and paying attention to the process of concept formation and application. Meng and Cui (2019) try to construct a biology unit learning process centred on problem focus and

through the design of real-life scenarios, the practice of activity experiences, the attempt to explain and argue, and the emphasis on expression and transfer, to enhance the quality of high school biology classroom instruction.

In the implementation of core competencies in physics textbooks, the textbooks follow the laws of human development and use the learning of subject knowledge as the carrier. They designs a series of learning and practice activities through the creation of scenarios and the driving of problems, so that students can develop core competencies by analysing and solving real-life problems (Peng, 2020). The new physics textbooks further optimize the number of questions and exercise structures (Yang & Zhang, 2019). The organization and presentation of biology textbooks are designed to meet the cognitive laws and learning psychology of students, making them easy to teach and learn (Zhao & Tan, 2020). The biology textbooks are based on the development of competencies through concept learning, through the development of competencies through scenario creation, through the combination of infiltration and summary and abstraction to meet the requirements of core competencies, and through exercises to enhance core competencies (Tan, 2019). The number of exercises in the 2019 version of the chemistry textbook has been reduced, and scientific thinking and scientific practice have been emphasized in the examination, with the scope and depth of core competencies being rationally expanded (Yang, Yang, Li, & Wang, 2021).

Xiao and Yan (2017) and Fan (2020) both propose creating problem scenarios through inquiry-based teaching, hands-on experiments and exploration, and experiencing scientific spirit and methods to develop high school students' core competencies in biology. Tan (2018) suggests that cultivating students' core competencies requires support from biological concepts and convergence in values, character, and ability. Shan, Yan, and Zheng (2019) find through a survey that there is generally insufficient emphasis on organic experiment teaching in high school, and teachers lack awareness of cultivating students' core competencies through organic experiment teaching. Wang and Wei (2018) explicitly propose that students must perform experiments, and teachers based on themes design teaching strategies, learning activities, and contextual materials to cultivate students' core competencies in chemistry. Nie (2017) argues that, under current conditions, supplementary measures should be taken to showcase the overall picture of physics knowledge system and internalize the continuous historical skeleton of physicists' thinking and research methods. Compared with the three-dimensional course objectives, the connotation of subject core

competencies is more profound and rich, and it can better highlight the educational function of the course. In the frontline teaching, it is necessary to pay attention to mining the subject core competencies of physics discipline contained in the teaching content, reflecting the connotation and core value of physics courses, and constantly paying attention to cultivating the subject core competencies of students (Liao, Li, & Li, 2019). Bi (2021) proposes that learning activities, content, and outcomes should be closely integrated to fully utilize the functions of chemistry teaching objectives and provide scientific guidance for achieving teaching-learning-evaluation integration.

Although many teachers and researchers have participated in the interpretation of core competency connotation and proposed corresponding suggestions, (Yang, Xu, & Li, 2021) found that middle school teachers have always been the main force in these research; Theoretical research is relatively lacking; Research on scientific thinking is more abundant, while attention to scientific attitude and responsibility is lower; There have been more studies on course construction and teaching methods, while less attention has been paid to research on teaching technologies and teacher development. The curriculum reform calls for further research on the integration of the core competences concept into teaching and evaluation.

2.4.5 *Summary*

This section reviewed curriculum reforms based on core competencies which is China's focus and starting point for this curriculum reform. I also reviewed curriculum reform experiences from other countries and regions to support the understanding of the reform in China. In the last section of the literature review chapter, I defined review model curriculum evaluation to establish the curriculum evaluation framework of this study align with the theoretical curriculum framework.

2.5 Curriculum Evaluation

2.5.1 *Definition of Curriculum Evaluation*

Evaluation can be simply defined as determining the value of something. Tyler (1949, pp. 105-106) identified that evaluation is ‘determining to what extent the educational objectives are actually being realized by the program of curriculum and instruction’. Taylor emphasized the objective orientation of curriculum evaluation and proposed that ‘evaluation is the process for determining the degree to which these

changes in behaviour are actually taking place' (Tyler, 1949, p. 106). '[E]valuation involves getting evidence about behaviour changes in the students, any valid evidence about behaviours that are desired as educational objectives provides an appropriate method of evaluation' (Tyler, 1949, p. 107). Cronbach gave a definition based on operational considerations, Cronbach (1983, p. 101) defined 'evaluation broadly as the collection and use of information to make decisions about an educational'. The Chinese scholar Shi (1996) concurs with Taylor's assertion that evaluation is a dynamic process, contending that curriculum evaluation is the process of studying the value of a curriculum, encompassing activities aimed at assessing its impact on student learning outcomes. While the primary purpose of evaluation is to assess the value of something, it can serve multiple functions within the curriculum. These include diagnosing curriculum, revising the curriculum, comparing the relative value of different courses, anticipating educational requirements, and determining the extent to which course objectives are achieved.

This section mainly discusses two issues: (1) the orientation of curriculum evaluation, which involves some basic views on evaluation. Diverse evaluation views would lead to various evaluation means, techniques and methods. (2) The mode of curriculum evaluation introduces several main methods and steps of curriculum evaluation and analyses their respective attributes.

2.5.2 *The orientation of curriculum evaluation*

While evaluation is primarily a methodological rather than content-oriented activity, the same evaluation procedure can be applied to assess the effectiveness of various elements. Ultimately, in determining the value of the curriculum plan, educators must ask: is the desired outcome worth the effort and resources?

However, individuals' processing of data is influenced by their philosophical and psychological perspectives. Behaviourists or proponents of prescriptive and sequential evaluation methods may insist on specific curriculum items being listed and clear objectives being stated to establish precise indicators of whether intended objectives are being achieved in curriculum plan. Conversely, a humanist is inclined to prioritize the impact of the curriculum plan on the student's self-concept, and therefore may not place significant emphasis on certain student achievements validated by specific, objective assessments.

However, whether the focus is on student achievement or student self-concept,

evaluators must carefully plan how to acquire the necessary evidence for making judgments; how to effectively communicate with students, teachers, and other stakeholders about the curriculum's effectiveness; how to execute the evaluation process; and how to establish criteria for assessing curriculum plans. Cronbach (1983, p. 102) identified three types of decisions to be made during evaluation:

1. Course improvement: deciding what instructional materials and methods are satisfactory and where change is needed.

2. Decisions about individuals: identifying the needs of the pupil for the sake of planning his instruction, judging pupil merit for purposes of selection and grouping, acquainting the pupil with his own progress and deficiencies.

3. Administrative regulation: judging how good the school system is, how good individual teachers are, etc.

'[E]valuation is a diversified activity' (Cronbach, 1983, p. 102). When conducting evaluation with a focus on enhancing the curriculum plan, the immediate objective is to assess the impact of the curriculum plan and determine whether it aligns with the intended objectives. Such evaluations enable educators to comprehend the effects of the curriculum plan and identify factors influencing its efficacy, thereby facilitating necessary adjustments. At times, educators may need to investigate how a teacher's behaviour and attitude towards specific curriculum content could influence students' access to that content through evaluation; or they may need to ascertain whether students with learning styles benefit from mastering certain curriculum material. Educators can also utilize evaluation to identify areas for improvement in curriculum plan management and implementation procedures.

Educators demonstrate a fundamental orientation in their evaluation, with typical orientations including scientism and humanism, intrinsic evaluation and pay-off evaluation, as well as formative evaluation and summative evaluation.

Scientistic Approach and Humanistic Approach

Scientistic Approach and Humanistic Approach can be seen as opposite ends of the evaluative spectrum (Ornstein & Hunkins, 1988).

Researchers with a Scientistic Approach adhere to the use of empirical experiments, typically focusing on outcomes or effects. The curriculum evaluation employs an experimental approach with the aim of comprehending the results of experimental treatment. In order to ensure the reliability and validity of the evaluation

results, it is essential to control for various external variables within the curriculum that may potentially confound individuals' understanding of the relationship between experimental treatment and its corresponding results. Furthermore, the evaluator must maintain an impartial stance and refrain from imposing personal beliefs. It is believed that only through this approach can the evaluation findings be deemed accurate. Scientistic researchers tend to direct their focus towards the student and frequently utilize test results as primary evidence for comparing student performance across various contexts. The data collected is quantitative, enabling it to undergo scientific analysis, comparison, and serving as a basis for curriculum decisions.

Researchers with a humanist or naturalistic approach contend that experiments are deemed unacceptable due to the complexity and interconnectedness of social phenomena, rendering it impossible to study them in isolation. They advocate naturalistic case studies, asserting that understanding human behaviour necessitates situating it within its original context. Furthermore, they posit that personal subjective biases cannot be entirely eradicated by the evaluator. Therefore, proponents advocate for evaluators to engage directly with the real-world context. This approach entails examining the curriculum plan from the perspective of its designers and implementers. The data collected in naturalistic evaluation is predominantly qualitative rather than quantitative, commonly obtained through conversations and discussions with participants. Additionally, subjective impressions gathered from various observations are considered valuable material for evaluation. As a result, this approach places greater emphasis on descriptive accounts of the actual situation rather than on statistical analysis.

In contemporary times, a minority of researchers espouse either of these two polarized assessment perspectives. Typically, evaluators of curriculum tend to occupy a position that falls within the spectrum between these extremes.

Intrinsic evaluation and pay-off evaluation

Intrinsic evaluation involves a direct assessment of the curriculum plan, seeking to address the question, ‘What are the strengths of the curriculum plan?’ Scriven (1967) illustrates intrinsic evaluation using the example of studying an axe. When examining an axe, individuals can analyse its design, materials used, weight distribution, and handle shape and fit. It is reasonable to assume that a well-designed and carefully selected axe efficiently cuts wood without directly measuring cutting wood. Similarly,

curriculum evaluators may assess the quality of a curriculum plan in terms of its specific content inclusion, accuracy of curriculum material, organization structure, student experience, and teaching resources incorporated. It can be inferred that well-designed and organized curriculum plans with a strong foundation are likely to effectively facilitate student learning.

While the rationale for the evaluator's involvement in the intrinsic evaluation (to ascertain the efficacy of the curriculum) may seem self-evident, it is not always fully acknowledged. The focus is not on identifying positive aspects of this curriculum, but instead on evaluating how effectively the curriculum truly fulfils its objectives, thereby placing emphasis on scrutinizing the outcomes of curriculum implementation. Scriven (1967) calls this pay-off evaluation. Outcomes are commonly defined in operational terms. Outcome evaluation is used primarily to examine the outcomes of curriculum plans for students. However, it can also be used to examine the outcomes for teachers and administrators. This evaluation orientation is generally judged by differences between pre- and post-test, experimental group and control group, or other standard parameters. Outcome evaluation is a reliable evaluation, because it provides reliable information to determine the outcome of the curriculum for the student.

Intrinsic evaluators argue that the intrinsic value of curriculum lies in the curriculum material, rather than solely in the outcomes achieved. When assessing curriculum, it is preferable to focus on the content rather than relying solely on student grades, particularly given the limitations of current testing tools and scoring procedures. However, outcome evaluators contend that it is difficult to unequivocally justify the value of specific curriculum content, as the question of 'what knowledge is most valuable' has been debated for centuries without resolution. Therefore, evaluation should aim to objectively document students' actual attainment of specified objectives, which provides reliable data. However, ‘the ‘payoff’ may be diffuse, long delayed; or it may be ever beyond the scrutiny of evaluators’ (Stake, 1993, p. 294). Outcome evaluation tends to prioritize short-term results over long-term outcomes and does not align with the extended duration of schooling.

Formative evaluation and summative evaluation

Formative evaluation refers to the evaluation activities conducted with the aim of enhancing the current curriculum plan (Saylor, 1991). It is a process-oriented evaluation intended to provide evidence for determining necessary revisions to the curriculum plan,

rather than assessing its overall quality. This necessitates collecting information at various stages of curriculum design in order to make adjustments prior to implementation. Formative evaluation can offer specific and detailed feedback during curriculum design and early experimental stages, enabling curriculum developers to address issues as they arise. Additionally, it allows for monitoring students' mastery of curriculum content during implementation and identifying additional learning needs in order to achieve desired outcomes.

Formative evaluation can be utilized to assess the design of a curriculum unit, with the evaluation being informal and involving only the teachers and students participating in the unit, or to evaluate a new curriculum plan, in which case the evaluation can be more formal and systematic, involving all stakeholders.

Formative evaluation is particularly well-suited for informing the development and refinement of curriculum. It also facilitates teacher engagement in course evaluations, not only for determining whether anticipated goals are being achieved but also for documenting unanticipated outcomes. As curriculum plans are primarily adjusted and modified based on the feedback, it fosters an open approach to curriculum development among teachers, thereby mitigating resistance to curriculum implementation.

Summative evaluation, also known as finality evaluation, assesses the impact of the curriculum plan post-implementation. This ex-post evaluation aims to provide a comprehensive assessment of the quality of the curriculum developed (Saylor, 1991). Typically conducted after the completion and implementation of the curriculum plan within a specific scope, it focuses on determining the overall effectiveness of the curriculum plan to draw conclusions about its efficacy.

Neither formative evaluation nor summative evaluation refers to some specific evaluation methods, but to their role in the curriculum development process. Formative evaluation is concerned with the cause of curriculum issues, and summative evaluation is concerned with the degree of curriculum issues. The results of formative evaluation are mainly used by the curriculum compiler to improve the curriculum, and the results of summative evaluation are mainly used to provide the basis for the curriculum decision makers to formulate policies. Formative evaluation is concerned with the improvement of the curriculum plan, and summative evaluation is concerned with evaluating the overall effect of the curriculum plan. Finally, while summative evaluation is typically conducted post-completion of the course plan, it should not be

limited to a single occurrence; rather, it can also be implemented at the conclusion of each stage within the curriculum development process.

2.5.3 *Curriculum Evaluation Models*

Due to its potential to enhance the curriculum design and elevate the standard of school education, curriculum evaluation has garnered significant attention from educators, leading to the development of diverse evaluation models in practical application. This section provides an overview of several commonly employed modes of evaluation.

Objective evaluation

Objective evaluation is based on Tyler (1949)'s evaluation and curriculum principles. The Evaluation Principles can be summarized into seven steps:

1. Determine the objectives of the educational program;
2. Defining each objective in terms of behaviour and content;
3. Identifying the context in which the objective is applied;
4. Designing the presentation of the situation;
5. Developing methods for collecting data;
6. Determining the scoring system used in evaluation;
7. Designing methods for obtaining representative samples.

Taylor's evaluation principle is objective-cantered, proposed in response to the limitations of norm-referenced tests prevalent in the early 20th century. Originating from intelligence tests, norm-referenced tests are primarily focused on student categorization and offer limited insight into student progress and educational program improvement. In contrast, objective-referenced testing has the potential to address these shortcomings. Building upon this evaluation principle and informed by curriculum development practices, Taylor introduced a more impactful curriculum principle.

Taylor's curriculum and instruction principles revolve around four central questions. He believes that participation in curriculum development activities must answer:

1. What educational purposes should the school seek to attain?

2. What educational experiences can be provided that are likely to attain these purposes?

3. How can these educational experiences be effectively organized?

4. How can we determine whether these purposes are being attained?

(Tyler, 1949, p. 1)

Taylor refrains from directly addressing these inquiries, as the responses are contingent upon the specific educational institution and developmental stage. Instead, he provides a framework and methodology for posing such questions, which underpins the fundamental principles of curriculum and instruction.

These four questions can be viewed as four steps or stages of the curriculum development process:

1. Objective determination;
2. Selection experience;
3. Organizational experience;
4. Evaluation results.

Taylor's principle is essentially a further elaboration of these four steps. Defining the goal is the most critical step, because all the other steps are stated around or immediately following the goal. 'The process of evaluation begins with the objectives of the educational program ... Definition of objectives, then, is an important step in evaluation.' (Tyler, 1949, pp. 110-111)

Evaluation can be seen not only as the fourth stage of the process, but in fact, the first three steps can be considered as the intermediary or initial stages of evaluation. Given that evaluation begins with defining the objective, it is essential for the objectives to be clearly defined. If the objectives are ambiguous, the first step in evaluation is to establish clear objectives to assess their actual attainment. The second step involves determining the context of evaluation so that students have an opportunity to demonstrate behaviours aligned with these objectives. Taylor places particular emphasis on the tools or methods of evaluation, as they directly impact the reliability and validity of evaluation results. He stresses that only after completing the steps can existing evaluation tools be scrutinized to determine the appropriate approach for obtaining relevant evidence. Furthermore, unless the evaluation method aligns with the curriculum objectives, the resulting evaluations can be seen as ineffective. Therefore, evaluation aims to ascertain to what extent intended curriculum objectives correspond with actual outcomes.

Objective evaluation emphasizes the use of clear and specific behaviours to articulate the objectives. The purpose of evaluation is to identify discrepancies between actual outcomes and curriculum objectives, using this feedback as a basis for revising

the curriculum plan or adjusting the objectives. This model has long dominated the curriculum field due to its ease of operation and effectiveness; however, it has been criticized for its narrow focus on intended goals at the expense of other factors. Furthermore, if evaluations are cantered solely on goals, how can we judge their rationality? In fact, most subsequent evaluation models have emerged as critiques or reflections of the objective evaluation model.

Goal-free Evaluation

Scriven (1967) proposed goal-free evaluation as a response to the limitations of the objective evaluation model. He argued that evaluators should focus on the actual impact of the curriculum plan rather than its intended effect, for example, the originally set goal (Scriven, 1972). According to Scriven, the objective evaluation model only considers the anticipated effect and overlooks any unexpected or side effects. He observed that some curriculum plans successfully achieved their goals but also resulted in harmful side effects, while others failed to achieve desired outcomes but produced valuable unintended results. Consequently, he concluded that evaluating based on predetermined objectives is not only unnecessary but potentially detrimental as it confines evaluators to curriculum objectives, restricts the scope of evaluation, and diminishes its significance.

Scriven advocated for the utilization of goal-free evaluation, shifting the focus from the anticipated outcome of the curriculum plan to the actual outcome of the curriculum plan. Evaluators should remain impartial to the intended curriculum objectives, as these may be beneficial in curriculum development but are not suitable criteria for evaluation. It is essential for evaluators to gather comprehensive information on the actual outcomes of the curriculum plan, regardless of whether they align with expectations or not, and irrespective of their positive or negative nature. Only through this approach can accurate judgments be made regarding the curriculum plan.

Context, Input, Process and Product (CIPP) Model

The CIPP model, as proposed by Stufflebeam (1971), encompasses Context Evaluation, Input, Process, and Product evaluation (CIPP). Stufflebeam emphasizes that evaluation should not solely focus on measuring the attainment of objectives but should also serve as a means to provide valuable information for curriculum decisions. Therefore, he underscores the significance of furnishing evaluative materials for curriculum decision-making. The CIPP model entails four distinct steps for gathering

pertinent materials (Stufflebeam, 1993, p. 124):

I. What needs were addressed, how pervasive and important were they, and to what extent were the project's objectives reflective of assessed needs (addressed by context information)?

It is essential to conduct a context evaluation in order to ascertain the organizational context of curriculum plan implementation. This involves clarifying the evaluation targets and their specific needs, identifying opportunities to address these needs, diagnosing any fundamental issues, and determining whether the objectives adequately reflect these requirements. The emphasis in context evaluation lies in assessing the curriculum objectives themselves against the needs of the evaluation subjects to ensure alignment between the two.

2. What procedural and budgeting plan was adopted to address the needs, what alternatives were considered, why was it chosen over them, and to what extent was it a reasonable, potentially successful, and cost-effective response to the assessed needs (addressed by input information)?

Input evaluation serves primarily to assist decision-makers in selecting the most effective approach to achieving their objectives, as well as evaluating various alternative curriculum plans. This phase involves asking questions such as: 'What alternative plans have been considered? Why were this particular plan chosen over others? How feasible is this plan? What is the likelihood of its success?' This stage can be viewed as an assessment of the feasibility of the curriculum plan.

3. To what extent was the project plan implemented, and how and for what reasons did it have to be modified (addressed by process information).

Process evaluation primarily aims to identify or anticipate issues within the curriculum plan or its execution by documenting the actual process. This includes assessing whether relevant activities are carried out according to the scheduled plan and if existing resources are utilized effectively. The goal is to provide decision-makers with valuable insights for revising the curriculum plan. Therefore, it is essential to continuously monitor the implementation of the plan.

4. What results - positive and negative as well as intended and unintended were observed, how did the various stakeholders judge the worth and merit of the outcomes, and to what extent were the needs of the target population met (product information)?

Product evaluation, that is, to measure, interpret and judge the achievement of the curriculum plan. It collects descriptions and judgments related to outcomes, relates

them to objectives and information about context, inputs, and processes, and explains their value and merits. Product evaluation is still a means of quality control, not just final identification.

Table 2.5

Four Types of Evaluation

	Context Evaluation	Input Evaluation	Process Evaluation	Product Evaluation
Objective	To define the institutional context, to identify the target population & assess their needs, to identify opportunities for addressing the needs, to diagnose *problems* underlying the *needs*, & to judge whether proposed objectives are sufficiently responsive to the assessed needs.	To identify & assess system *capabilities,* alternative program *strategies*, procedural *designs* for implementing the strategies, budgets, & schedules.	To identify or predict, in process, *defects* in the procedural design or its implementation, to provide information for the pre-programed decisions, and to record & judge procedural events & activities	To collect descriptions & judgments of outcomes & to relate them to objectives & to context, input, & process information; & to interpret their worth & merit.
Method	By using such methods as system analysis, survey, document review, hearings, interviews, diagnostic tests, & the Delphi technique.	By inventorying & analysing available human & material resources, solution strategies, & procedural designs for relevance, feasibility & economy; and by using such methods as literature search, methods as literature search, visits to exemplary programs, advocate teams, & pilot trials.	By monitoring the activity's potential procedural barriers & remaining alert to unanticipated ones, by obtaining specified information for programmed decisions, by describing the actual process, & by continually interacting with & observing the activities of project staff.	By defining operationally & measuring outcome criteria, by collecting judgments of outcomes from stakeholders, & by performing both qualitative & quantitative analyses.
Relation to Decision-making in the Change	For deciding upon the *setting* to be served, the goals associated with meeting needs or using opportunities, & the	For selecting *sources* of *support*, solution *strategies*, & procedural *designs*, i.e., for *structuring* change activities; and to provide	For *implementing and refining the program design and procedure*, i.e., for effecting *process control*; & to provide a	For deciding to *continue, terminate, modify, or refocus* a change activity, &

Process	*objectives* associated with solving problems, i.e., for *planning* needed changes; and for providing a basis for judging outcomes.	a basis for judging implementation.	log of the actual process for later use in interpreting outcomes.	present a clear record of effects (in- tended & unintended, positive & negative).

(Stufflebeam, 1993, p. 129)

The CIPP evaluation model considers various factors influencing the curriculum plan, and can compensate for the limitations of other evaluation models, making it relatively comprehensive. However, its complex operational process makes it challenging for ordinary individuals to master.

Stake's Countenance Model

Stake (1967) proposed the countenance evaluation model, which suggests collecting curriculum materials from three aspects: antecedents, transactions, and outcomes of the program. Antecedents encompass conditions existing before teaching that may have a causal relationship with the outcome. Transactions pertain to the teaching process, specifically the relationships between teachers and students and among students. Outcome refers to the impact of implementing the curriculum plan. Evaluation of these aspects should include both description and judgment. Description encompasses what the curriculum plan aims to achieve as well as observed outcomes, and judgment bases on established standards as well as actual circumstances. The complete evaluation model is presented in Table 2.6.

Table 2.6

Stake's Countenance Model

	Description		Judgment	
	Intended	Observed	Logical	Empirical
Antecedents (Characteristics of teachers and students, curriculum content and materials, social context, etc.)				
Transactions (Transaction process, time allocation, time series, social atmosphere, etc.)				
Outcomes (Student academic performance, mindset, physical abilities, impact on educators and educational institutions, etc.)				

According to the countenance evaluation model, curriculum evaluation activities involve the observation and collection of data throughout the entire curriculum implementation process. This extends beyond simply assessing teaching outcomes, instead focusing on describing and

evaluating various dynamic phenomena within the teaching process. By taking into account both pre- and post-curriculum implementation materials as reference points, this model demonstrates a more comprehensive approach compared to previous evaluation models. However, it relies heavily on personal observation and descriptive judgment as the primary basis for evaluation, which may introduce subjective biases. Furthermore, the boundaries of antecedents, transactions, and outcomes factors are not absolute; rather, the transactions or teaching process involves numerous antecedents and outcomes.

Discrepancy Evaluation Model

The Discrepancy Evaluation Model was proposed to highlight the limitation of some evaluation models that solely focus on comparing different curriculum plans without considering the components within the program. It is noted that certain schools claiming to have a curriculum plan may not adhere to it in practice, rendering comparisons between such plans meaningless. The Discrepancy Model aims to identify discrepancies between the program standards and actual performance, serving as a foundation for enhancing the curriculum plan. The Discrepancy Evaluation Model comprises five stages for comprehensive evaluation (Buttram & Covert, 1978):

The first stage is the program design, which involves defining the curriculum plan standards as the basis for evaluation. The standard refers to the essence of the curriculum plan and comprises three components: the objectives of the curriculum plan (expected outcomes), human and material resources required to achieve these objectives (prerequisites), and activities conducted by teachers and students to attain goals (teaching processes). A comprehensive delineation of these three elements, as described by Provos, constitutes definition. Once defined, it serves as the benchmark for evaluation. With these standards in place, educators can assess whether the curriculum plan aligns with them effectively.

Installation evaluation is the second stage, during which it is essential to assess the degree to which the implemented curriculum plan aligns with its original intention. Therefore, it is imperative to gather relevant materials pertaining to the installed curriculum plan, including anticipated objectives, prerequisites, and teaching procedures.

The third is process evaluation, to understand whether the intermediate goal leading to the

final goal has been achieved, and to further understand the relationship between the prerequisite, the teaching process, and the learning outcome, to adjust these factors. The focus of this stage is to understand whether the teaching activity is producing the desired outcomes.

The fourth stage involves product evaluation, which assesses the achievement of the final goal of the implemented curriculum plan. The objective in the installation and process stages is to ensure the effective and stable existence of plan components, while product evaluation aims to determine their actual outcomes for comparison with the final objectives.

The fifth phase entails cost-benefit analysis or plan comparison, aiming to demonstrate the most cost-effective plan through comparison with various alternatives.

Apart from the final phase, the initial four phases entail the identification of standards and actual performance, comparison of discrepancies between the two, exploration of underlying reasons for such discrepancies, and determination based on these findings whether to proceed with the subsequent phase, repeat the current phase, or terminate the entire program.

The discrepancy evaluation model focuses on the disparity between the expected standards of the curriculum plan and the actual performance at each stage, while also considering the underlying causes of this disparity to inform timely and rational decision-making. It is a feature not commonly found in other evaluation models. However, navigating the value judgments inherent in assessing this dissonance between intended and actually poses a challenge that is not easily addressed by conventional evaluation methods.

Naturalistic inquiry

After developing the countenance evaluation model, Stake gradually immersed himself in a new evaluative approach that he termed responsive evaluation. Stake (1993, pp. 291-292) stated that

'[T]here are many different ways to evaluate educational programs. No one way is the right way. Some highly recommended evaluation procedures do not yield a full description nor a view of the merit and shortcoming of the program being evaluated. Some procedures ignore the pervasive questions that should be raised whenever educational programs are evaluated of the program being evaluated. Some procedures ignore the pervasive questions that should be raised whenever educational programs are evaluated.'

The evaluators prioritize the impact of the assessment on the relevant public interest over its objectives (Guba & Lincoln, 1981). Education gradually evolved into a national phenomenon.

'I prefer to work with evaluation designs that perform a service. I expect the evaluation study to be useful to specific persons. An evaluation probably will not be useful if the evaluator does not know the interests of his audiences. During an evaluation study, a substantial amount of time may be spent learning about the information needs of the persons for whom the evaluation is being done. The evaluator should have a good sense of whom he is working for and their concerns.' (Stake, 1993, p. 292)

The concerns and issues of responsive evaluation lies in addressing the concerns and issues arising from the diverse stakeholders that the evaluation aims to serve (Guba & Lincoln, 1981). They defined the major purpose of evaluation 'as responding to an audience's requirements for information, particularly in ways that take account of the several value perspectives of its members' (Guba & Lincoln, 1981, p. 36).

The evaluation model of naturalistic inquiry is grounded in phenomenology, hermeneutics, analytic philosophy of everyday language, and symbolic interaction theory. Naturalistic inquiry posits that the strictly scientific method of inquiry is only one among numerous ways in which humans seek knowledge. The fundamental assumptions underlying this inquiry model include (Guba & Lincoln, 1981):

Firstly, social reality is diverse and can only be comprehensively studied as a whole; studying only a few variables and processes independently would inevitably deviate from the essence of the problem.

Secondly, the subject and object of study interact with and influence each other; they cannot be completely separated, nor should they be.

Thirdly, social science research cannot be divorced from questions of value; its purpose is indeed to contribute to a more valuable society—value neutrality does not exist.

Fourthly, social action arises from a combination of factors, and appropriate inferences can only be drawn when placed within their context.

The aim of inquiry is not to establish a universal knowledge system governed by eternal laws that transcend specific situations but rather to develop unique understandings suited for solving particular problems. Therefore, conducting field research and providing actual descriptions of

social action within its natural context are considered optimal approaches for evaluation purposes.

Naturalistic inquiry does not advocate for fixed research methods but instead emphasizes tailoring them according to specific circumstances. Henceforth it can be regarded as not merely an evaluation model but rather as a comprehensive research methodology. In terms of evaluation criteria, naturalistic inquiry exhibits several key features:

1. Prioritize the investigation of naturalistic scenarios rather than artificially manipulating variables to construct testable situations.

2. Emphasize qualitative research methods over quantitative approaches.

3. Focus on deriving theories from empirical evidence instead of deducing hypotheses from existing theories and subsequently confirming them through experimentation.

4. Concentrate on case studies rather than large-scale surveys.

5. Acknowledge the significance of tacit knowledge such as intuition and feeling, in addition to propositional knowledge conveyed through language.

6. Develop the research design incrementally with each subsequent step based on findings from preceding steps rather than pre-determining each stage independently.

7. Actively engage as a participant within the research context to foster empathetic effects instead of maintaining an objective distance.

The methods of naturalistic inquiry for data collection encompass observation, interviews, investigations, indirect measurement, etc., each with their distinct understanding and interpretation regarding the credibility, generalizability, verifiability, and objectivity of research findings.

All the curriculum evaluation models possess both advantages and disadvantages. Some models are user-friendly but solely focus on immediate and observable effects. Conversely, other models offer a more comprehensive approach but entail a complex implementation process. Additionally, it is challenging to ascertain whether personal subjective factors have infiltrated the research process. Consequently, it is crucial to select appropriate evaluation methods based on the specific object under evaluation.

Science Curriculum Evaluation Framework of this study introduced in Chapter 3 Methodology.

2.5.4 *Evaluation applications of curriculum reforms*

To gain a more comprehensive understanding of the application of curriculum evaluation models, I conducted a thorough review of research on science curriculum reform evaluations in various countries and regions. I carefully selected representative content that is directly relevant to this study and focused on discussing the data collection methods and research approaches employed for different research subjects. In the subsequent chapter, I established a curriculum evaluation model for this study and choose appropriate research methods accordingly. This necessitates building upon sufficient theoretical and practical foundations, thus ensuring that this section progresses from specific evaluations to more comprehensive ones.

Education policy research in Michigan

Addonizio and Kearney (2012) reflect on the various policy reforms implemented in the United States, particularly in Michigan, over the past 40 years. During this period, the US has undergone policy innovations in education finance reform, a series of school accountability measures, charter schools, and schools of choice. They discuss these core policy values of educational efficiency and accountability, equity, adequacy, and choice. However, they point out that despite widespread acceptance of accountability in education, there are many doubts about the design and implementation of existing accountability systems. Under the No Child Left Behind Act (NCLB), Michigan's requirements for educational reform have raised widespread concerns regarding how to ensure that all students can achieve expected academic levels. The article emphasizes the interrelationship between efficiency and accountability and argues that the efficiency of an education system directly affects public satisfaction with its use of resources. The authors explore whether policy reforms are fair in resource allocation and whether they can provide high-quality education for every student. The article analyses the availability and stability of educational resources while questioning whether existing policies can ensure that every student receives sufficient educational resources. While choice provides more options for students and parents, it may also exacerbate social inequalities especially concerning race and economic background. Overall, this article reflects on both achievements and limitations of educational

policy reforms while offering profound thoughts on prospects for public education in Michigan.

In China, there has also been systematic research on curriculum reform policies. For example, Tu (2009) conducted a study on curriculum reform through systematic literature research, theoretical analysis, comparative research, and case analysis. This study included research reports on curriculum reform, curriculum reform proposals, relevant laws and policy documents to delve into the internal processes and mechanisms of curriculum reform policies. From an integrative perspective, they expanded the general understanding of the process of curriculum reform policies by examining their different manifestations in terms of phenomenological form, ontological characteristics, and practical features. This challenges the traditional view of curriculum reform policies and regards the process as one that is generated and developed within specific contexts.

Teachers' Experiences of Science Curriculum in England and Scotland

In England, a significant reform has been implemented on the science curriculum for students aged 14-16, emphasizing the teaching of social science issues and the nature of science. This reform offers more course choices with the aim of enhancing students' scientific competencies. Ryder and Banner (2013) investigated the experiences and perceptions of teachers within the curriculum reform. This research analysed the external and internal factors that affect teachers' experiences of the curriculum reform. It aims to understand how teachers respond to the curriculum reform and the motives behind these responses. This study conducted interviews with 22 teachers from 19 schools in England, which show diversity in terms of student age range, overall student achievement and socioeconomic status. A semi-structured interview method was adopted in the research to conduct in-depth interviews with teachers and understand their views and experiences regarding curriculum reform. Through the analysis of the interview contents and utilizing Goodson's framework (2003), the personal, internal and external factors that influence teachers' responses to the curriculum reform were identified.

The research findings indicate that teachers' experiences with curriculum reform are influenced by complex interactions of personal, internal, and external factors, with their professional identity playing a significant role in shaping these experiences. Additionally, teachers' responses to curriculum reform go beyond acquiring new knowledge and teaching methods; they

also involve challenges to their professional identity. Therefore, curriculum reformers need to recognize the inevitability of multiple teaching goals in highly differentiated departments and school workplaces. Teachers' experiences with curriculum reform can extend beyond learning new knowledge and teaching methods to include challenges to their professional identity. Furthermore, teachers' responses to curriculum reform are a long-term process that requires at least several years for full implementation and evaluation.

Similarly, Wallace and Priestley (2017) collected data from seven science teachers using semi-structured interviews and classroom observations to explore the changes that occur in the role of teachers as curriculum developers when faced with new curriculum requirements. They also investigated the experiences of Scottish secondary school science teachers in curriculum development, including daily lesson design and broader curriculum planning, all within the context of educational reform.

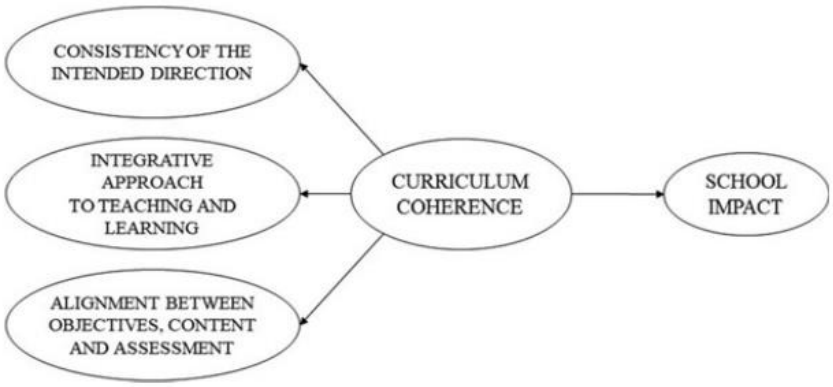
These studies have two noteworthy features. Firstly, although it focuses on teachers, the selection of research subjects includes teachers from multiple schools at different levels, ensuring the reliability of data analysis and conclusions. Secondly, it provides a profound understanding of how teachers experience and respond to science curriculum reforms, emphasizing the need to consider the diverse backgrounds of teachers' work when designing curriculum policy reforms and related professional development activities.

Large-scale curriculum reform in Finland

Jenni Sullanmaa and his colleagues (2019) delve into the perception of curriculum coherence by district-level stakeholders in Finland's large-scale national curriculum reform. Sullanmaa (2019) points out that curriculum coherence is crucial for successful educational reforms, yet empirical research on this topic remains insufficient. Their study aimed to fill this gap by investigating how stakeholders perceive curriculum coherence in district-level curriculum development and revealing its relevance and potential impact on school-level development, specifically the correlation and potential of reform efforts in school development.

Figure 2.6

Hypothesised Model



The study utilized structural equation modelling to analyse survey data (n = 550) obtained from district-level stakeholders participating in 12 case region curriculum development working groups. Confirmatory factor analysis revealed that curriculum consistency consists of three complementary components: consistency of the intended direction, an integrative approach to teaching and learning, and alignment between objectives, content, and assessments. Furthermore, the research findings indicated that curriculum consistency has an expected contribution to the development of reforms at the school level.

The study reflects the consistency of large-scale curriculum reform，as Fullan (2009) reviewed large-scale reforms like NCLB and National Literacy and Numeracy Strategy (NLNS), The further deepening and expansion of large-scale reforms, not only in the education system but throughout the entire system.

"*For system reform in education such leadership must show up at all levels of the system—teacher leaders, principals, district administrators, and government including especially presidents, prime ministers, premiers, governors, ministers, state superintendents, director generals, deputy ministers and their direct reports"* (Fullan, 2009, p. 110).

Junior science reform evaluation in Hongkong (2003)

Lee (2003) conducted a systematic analysis of the reform of the Hong Kong junior secondary science curriculum based on the evaluation framework employed in TIMSS, which includes three levels: the intended, implemented, and achieved curriculum. This study collected and analyzed

qualitative and quantitative data using documentary analysis, planner interviews, teacher surveys and interviews, quasi-experimental studies, and student interviews.

His study indicated that the current educational reform aims to meet the individual, social, and educational needs in contemporary society. The new curriculum emphasizes the essence of science and focuses on its relevance to everyday life. It introduces inquiry-based learning with the aim of integrating students' understanding of concepts and skills, further expanding them in open contexts. However, there is a significant problem in implementing this approach due to large variations among teachers. Research highlights the importance of placing open inquiry activities at the core of curriculum design and adopting more practical approaches in teacher training to facilitate a shift from being knowledge providers to facilitators of student exploration.

His study has two implications for the research on curriculum reform in China. Firstly, he used various qualitative and quantitative research methods to target different research subjects. As Lee described, he viewed the implementers of the curriculum as actors in a drama, where each role played an indispensable part despite their limited stage time. Secondly, Hong Kong's curriculum reform is taking place during a unique historical period and due to its special context requires comprehensive and systematic evaluation of the curriculum to explore future development directions for scientific education. This situation is similar to what China currently faces - ensuring that previous educational systems remain unchanged while seeking international alignment - thus highlighting the importance of systematic and comprehensive curriculum evaluation for successful reform.

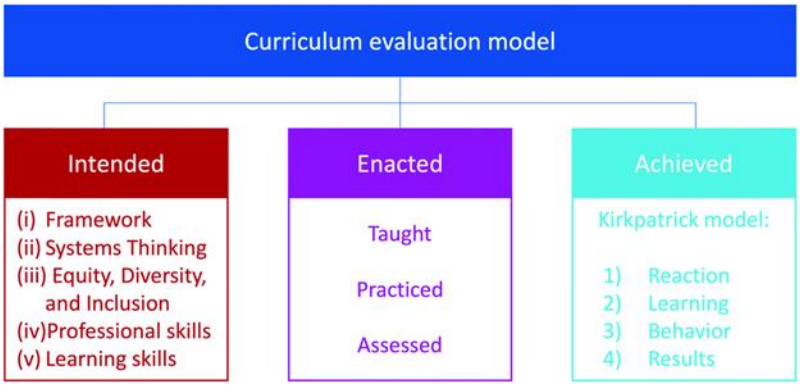
Evaluation model for science curricula reform in Cannada (2020)

Science education requires rapid transformation to accommodate the rapid changes in new information and technology. Meanwhile, traditional teaching formats fail to meet the demands of diverse learners. Raycroft and Flynn (2020) established a comprehensive model for the assessment of science curriculum by integrating curriculum assessment components in novel manners. The model assesses the intended, implemented, and enacted sections of science curriculum by analysing learning outcomes through five perspectives (Figure 2.8). This research applied the model to analyse the organic chemistry course at the University of Ottawa. Based on the Four Level Kirkpatrick model and using the Three-Dimensional Learning Assessment

Protocol (3D-LAP) to analyse the learning objectives (LOs) at each curriculum level to determine their capacity in stimulating scientific practices (SPs), cross-disciplinary concepts (CCs), and core concepts of the chemistry discipline (CIs), the intended, implemented, and enacted parts of the curriculum were evaluated.

Figure 2.7

Curriculum Evaluation model (Raycroft & Flynn, 2020)



Analysis from five perspectives has disclosed the strengths and potential deficiencies of the curriculum in various aspects and offered an evidence basis for curriculum reform. The implementation of the curriculum was in line with intended, suggesting that the curriculum was conducted in accordance with the intended learning outcomes. It has provided an evidence basis for improving the curriculum to better support students' learning. This research presents a comprehensive model for evaluating science curriculum by analysing learning outcomes from five perspectives for the purpose of assessment and improvement.

2.5.5 *Overview of Curriculum Evaluation*

As the last section of the literature review chapter, this section reviews the definition, theoretical models, and application research of curriculum evaluation. It serves as the theoretical and methodological foundation for establishing the curriculum evaluation framework in this study. It also corresponds to different stages and levels of curriculum reform, indicating that a systematic analysis and evaluation of large-scale curriculum reform requires corresponding and appropriate evaluation models and research methods. At the same time, curriculum evaluation should not only focus on comprehensiveness but also emphasize process and depth of evaluation. This requires that the curriculum evaluation framework should not simply adhere to rigid evaluation models but

make adaptive adjustments based on specific curriculum frameworks to better answer research questions. The establishment of an evaluation framework should be seen as an integration of these adjustments and methods. Furthermore, based on these reviews, it is necessary to use various data processing and analysis methods including qualitative and quantitative approaches while paying attention to potential influences from research hypotheses and data processing procedures.

2.6 Summary

Starting from the theories of curriculum and curriculum reform, this chapter traces the development path of curriculum reform in China. The development of Chinese curriculum is marked by a winding journey, and the three stages of curriculum reform are accompanied by diverse paradigms in global curriculum research. Beginning with 'objectives-content-implementation-evaluation' model (Tyler, 1949) for curriculum development, it progresses to theory of practical curricula (Schwab, 1969), process model (Stenhouse, 1975) and the concept of teacher as researcher, as well as Apple, Bourdieu, Giroux representing reproductive theory and critical pedagogy research. (Apple, 2019; Bourdieu et al., 2000; H. A. Giroux, 1991)

From the perspective of curriculum development, it is necessary to understand how to design curriculum objectives, curriculum content, teaching implementation, and curriculum evaluation. From a practical perspective, it is important to understand the negotiation and interaction process among different curriculum stakeholders in practice. From a process-oriented perspective, the focus is on continuously adjusting the educational process in order to maximize its effectiveness and facilitate maximum learning and development for students. This requires questioning what knowledge and methods are used in the curriculum to ensure equal access for everyone. The choices, organization, and transmission of knowledge represent certain value orientations. It can be observed that regardless of which perspective we take, these issues are interconnected. Therefore, in order to objectively evaluate curriculum reform comprehensively, attention should not only be given to curriculum design and development but also to underlying values as well as the connection between policymaking and classroom teaching in participating in curriculum reform.

Based on these principles, this chapter reviews the research on curriculum reform based on

core competencies in both international and Chinese contexts. Drawing upon the levels and sites of curriculum making, a three-level theoretical curriculum framework with six sub-levels for China's current curriculum reform is proposed. Finally, existing curriculum evaluation models are reviewed as references, and combined with the theoretical curriculum framework to describe in detail the curriculum evaluation framework and specific research methods of this study in the next chapter.

Chapter 3 Methodology

3.1 Introduction

In this chapter, methodological design and instruments used in this research are introduced based on literature reviews of curriculum/educational development history and curriculum theories. Firstly, this chapter describes the evaluation framework based on the curriculum framework discussed in the last Chapter and timeline with key events of this research. In the following sections, this chapter concludes and explains what evaluation strategies are used and how they are carried out at three curriculum levels (intended curriculum, implemented curriculum, attained curriculum) in this reform respectively. As objectives in this research include documents, principals, teachers, and students, this chapter also provides sampling and data collecting strategies. In the last section of this chapter, the pilot study discusses the feasibility of methods and adjustments for the teacher interview outline and student questionnaire.

3.2 The Evaluation Framework and Timeline

3.2.1 *Overview*

This section aims to introduce the evaluation framework for this reform as a foundation of this research design and the timeline. The evaluation framework, based on the levels of a curriculum framework, provides an overall framework for evaluations answering the research questions. Moreover, the timeline shows the key events of evaluation at three curriculum levels.

3.2.2 *The Curriculum Framework*

Scholars have conducted implementation studies from different perspectives. Research on curriculum implementation can be divided into three orientations: fidelity, mutual adaptation and curriculum enactment (Snyder et al., 1992). Accordingly, this

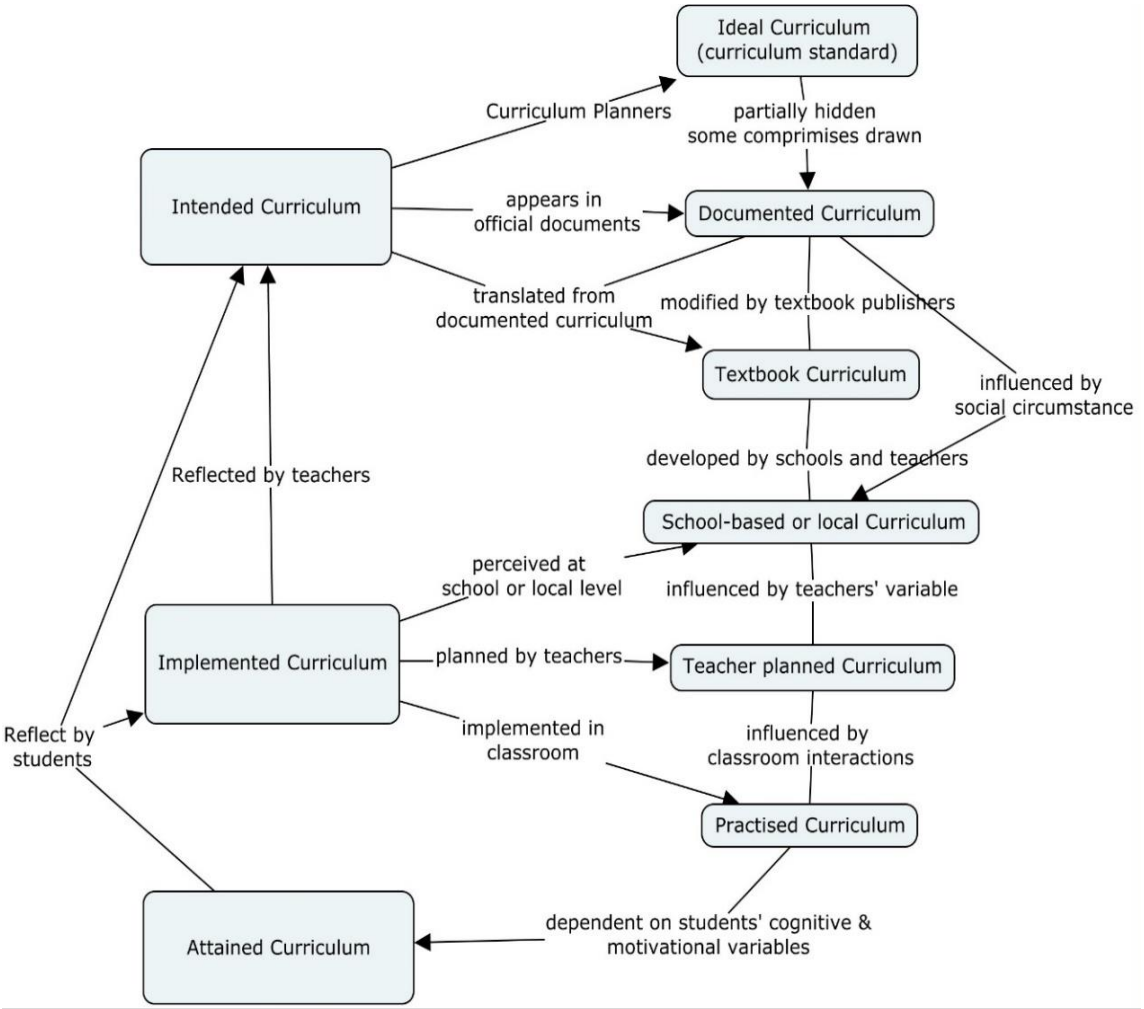
study focuses on implementation process from a fidelity orientation, examining the extent to which the perceived curriculum is implemented by schools and teachers while attained by students.

When considering the curriculum framework, I considered the specific situation in China and summarized it for the subsequent curriculum evaluation model. As reviewed of the three-level curriculum administration developed since the end of 1999, which shown in Table 2.1, my theoretical curriculum framework referred to the curriculum models of Lee (2003), which comprises three main levels of curriculum: Intended, Implemented, and Attained curriculum. I further develop 6 sub-levels: Ideal Curriculum, Documented Curriculum, Textbook Curriculum, School-based Curriculum or Local Curriculum based on the reference of Goodlad's curriculum level model (Goodlad, 1979) and Priestley's activities (Priestley, 2021). The detailed curriculum framework can be seen in the concept map

Figure 3.1.

Figure 3.1

The Curriculum Framework



The intended curriculum is divided into three sub-levels: ideal curriculum, documented curriculum, and textbook curriculum. Firstly, the ideal curriculum represents the curriculum plans and standards for the development of new curricula. These serve as both the theoretical foundation and practical guidance for national curriculum reforms, while also providing a basic direction for subsequent development of local curricula and school-based curricula. It also reflects the reform intentions of curriculum planners. Secondly, the documented curriculum aims to establish a comprehensive system for curriculum reform by clearly defining specific goals and tasks required for each reform theme. This is primarily manifested in official policy documents at the national level that oversee the implementation of curriculum policies

and organize national-level evaluations. The documented curriculum is revised according to educational reforms and developments as needed. Lastly, the textbook curriculum involves policies formulated by designated publishers regarding textbook writing, review, and selection processes based on national curriculum standards. While local authorities and schools have some degree of autonomy in selecting textbooks and developing school-based curricula, they still need to rely on official textbooks as a foundation. Therefore, I include the textbook curriculum within the intended curriculum to better reflect how curriculum standards and policy documents from a national perspective influence changes in new curricula.

The implemented curriculum is also divided into three sub-levels: the local and school-based curriculum, the teacher-planned curriculum, and the practiced curriculum. Firstly, the local and school-based curriculum serves as a transition from the national curriculum, providing plans for developing new curriculums at the local and school level. It also organizes reviews of school curriculum implementation plans, guides schools in implementing national or local curricula, selecting textbooks, and developing school-based curricula. Additionally, it provides services to support the implementation and development of school curriculums by helping schools address educational issues and organizing teacher training to learn about new curriculum content. At this stage, it mainly focuses on how schools accept and interpret policy documents for teachers. This transitional phase corresponds to Priestley's Micro site of activity (2021) where principals and middle-level leaders play a crucial leadership role (Fullan, 2016).

Secondly, the teacher-planned curriculum corresponds to specific processes of curriculum development, including selecting curriculum materials, supervising the implementation of lesson plans, teaching, assessment and examination, developing and utilizing curriculum resources. Additionally, it is necessary to establish a school curriculum management mechanism that includes teachers, students, parents and community representatives. In this study, the focus is mainly on the aspects related to teachers and students in the classroom environment which align with Goodlad's Operational Curriculum of Goodlad (1979).

Finally, the practiced curriculum, as a transition between the implemented curriculum and the attained curriculum, is manifested in the actual teaching and learning experiences and feedback of teachers and students in the new curriculum. As part of the implemented curriculum, it focuses on teachers' feedback on student learning and application of curriculum instructional design. The next level of curriculum places more emphasis on student-level situations. This section also corresponds to Priestley's (2021) nano site of activity of curriculum which primarily focuses on pedagogic interactions and curriculum events between teachers and students.

The attained curriculum mainly consists of two components: on one hand, it serves to align with the practiced curriculum. It primarily focuses on what students have attained from the implemented curriculum, including their outcomes, attitudes, and reflections on schooling and the curriculum. On the other hand, the impact of curriculum on students' self-awareness and future planning should also be considered. This corresponds to the experienced curriculum of Goodlad (1979), which focuses on students' experiences in the classroom. However, it is difficult to know what exactly students are thinking just by observing them and asking them may not guarantee valid answers. When exploring this aspect of curriculum, it is necessary to obtain data on interactions, such as whether the curriculum influences daily learning life, whether extracurricular activities contribute to the learning experience, and when student aspirations align with school resources. Instead of simply judging whether a school is doing well or not, it is more important to gather evidence about what students have learned and reflected upon through their engagement with the curriculum to determine what role schools should play.

In short, the three-level curriculum model represents the dynamic process of the curriculum at different stages and objectives. Furthermore, succession, feedback, and gap between these levels determine the efficiency and effectiveness of the curriculum implementation, especially during the period of curriculum reforms. In the following section, I provided a detailed introduction to the curriculum evaluation models and

research methods for each level corresponding to the curriculum framework.

3.2.3 *The Evaluation Framework of the reform*

Rationale of methodological design

Based on the three main levels and their sub-levels in the curriculum framework, I aim to conduct a systematic evaluation of curriculum reform. Barab and Squire (2016) argue that the nature of educational design involves creating new theories and practices through a series of approaches in a "naturalistic" environment. In Section 2.55, based on reviewing curriculum evaluation models and applications in different countries and regions, I propose that research methods should be used according to the research object. Therefore, I believe that using a mixed-method approach is the most ideal and suitable for evaluating and collecting data analysis at different levels of the curriculum. With the continuous emergence of evaluation theories and models, evaluation methods have also been greatly expanded (Kellaghan & Stufflebeam, 2003). Furthermore, For the application of mix-method approach, integrating data analysis strategies is a priority consideration for further utilization of mixed methods research (Greene et al., 1989). Therefore, I use the CIPP model as an overall strategy to integrate these analytical methods, as discussed in Section 2.5.3. It advocates that evaluation is a systematic tool that provides useful information for evaluators, making programs more effective. To carry out evaluation activities effectively, it is necessary to have a well-designed evaluation framework and implementation process. This highlights the developmental function of evaluation and integrates diagnostic evaluation, formative evaluation, and summative evaluation. These evaluations correspond to stakeholders in different curriculum levels including policy planners, principals, teachers and students. In the following section, I elaborated on the methods of data collection and analysis based on the curriculum framework and research questions. I also outline my timeline in the last of this section.

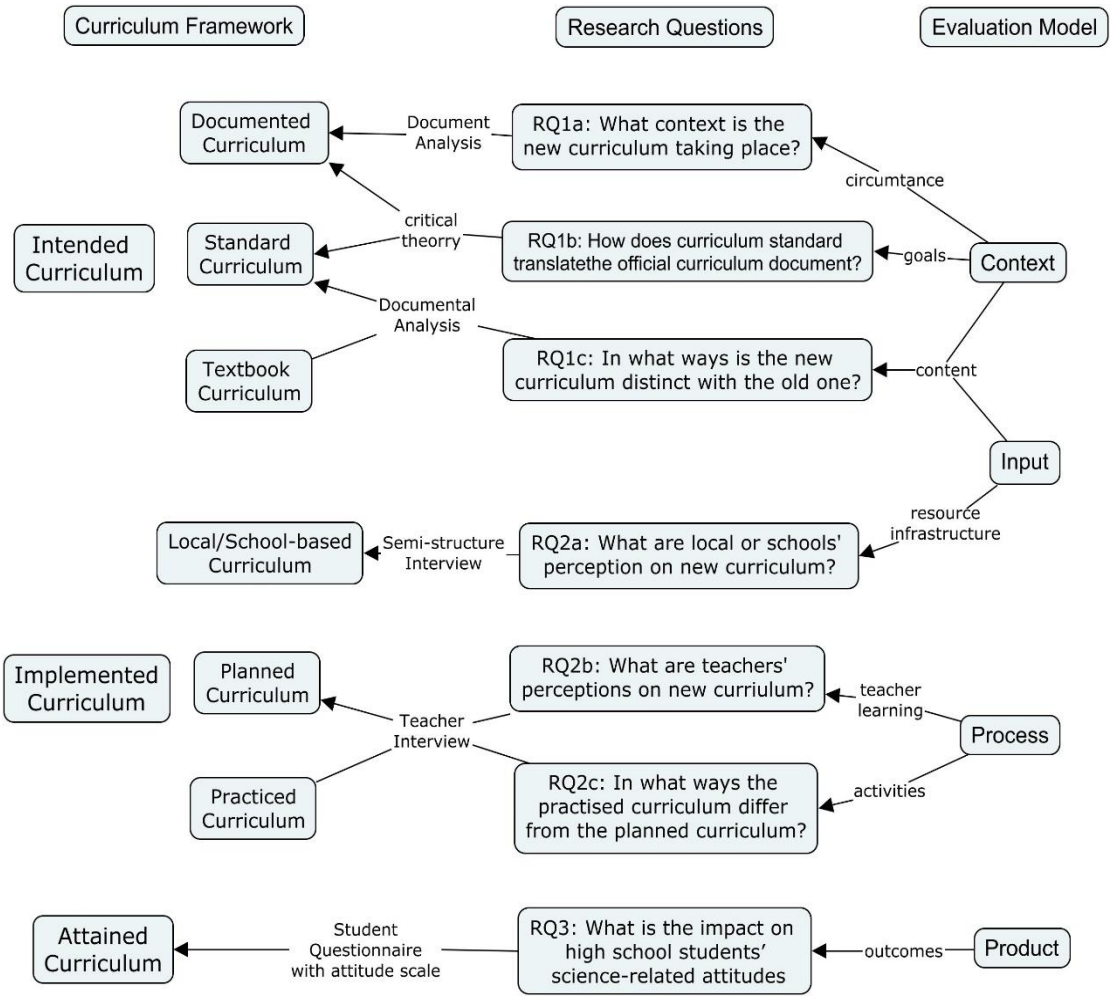
Answering the research questions developed with the CIPP evaluation model

As reviewed in Chapter two, schooling in China was given a prevailing metaphor

as a ‘garden’ and teachers as ‘gardeners’, which to some extent indicates the power of teachers in education. Fullan (2016) proposes that a traditional curriculum change model occurs in three phases: initiation, implementation, and continuation, which correspond to three levels of the curriculum framework in China (discussed in Chapter Two). A curriculum evaluation should be integrally involved in all phases of curriculum implementation (Tyler, 1989) and it should be illustrative for an innovative programme (Madaus, Scriven, & Stufflebeam, 1983). I construct the evaluation framework to focus on not only the student achievement but also the initiatives of this reform and teachers' experience with the CIPP (Context, Input, Process, Product) model proposed by Stufflebeam (1983). The evaluation framework is shown in Figure 3.2 below.

Figure 3.2

Evaluation framework



The CIPP evaluation model has four types: context, input, process, and product (Stufflebeam, 2003), which can be used in the formative and summative evaluation. As a reform implementation evaluation, using this model can be systematically helpful for attaching to the curriculum framework. In the following paragraphs, the research questions were elaborated with the CIPP model as a guideline of the evaluation framework.

RQ1 focuses on the intended curriculum at the national level. Specifically, it aims to contribute to exploring the social and political circumstances of the reform (RQ1a), the goals and missions of education development (RQ1b), and content translated into the curriculum (RQ1c). Context evaluation initiates to identify social needs and barriers to meeting these needs (Stufflebeam, 2003). In a national reform, the documented curriculum includes the context and domestic needs behind the national policy documents. Moreover, curriculum standards demonstrate the goals of the new curriculum and guideline for further development. Barriers of meeting the educational needs in curriculum standards can be identified from the context evaluation of national policy documents. Therefore, documentary analysis approach is used in analysing national policy documents from 2017 to 2020. Comparison of standards and textbooks between old and new curriculum mainly contain inquiry into educational goals, content and suggested activities. This is also the transition of the intended curriculum and the implemented curriculum and leads to the input evaluation.

The input evaluation aims to evaluate strategies and action by content, resources, and infrastructure in the programme (Stufflebeam, 2003). RQ2a focuses on perspectives at local and school level, where principals are responsible for receiving reform contents as well as the deployment of human resources and administration of infrastructure. Therefore, the perception of principals would illustrate the transition of the intended and implemented curriculum and play a vital role in the reform process. Principals are ‘expected to lead these very changes’, however, ‘change is only one of the forces competing for the principal's attention, and usually not the most compelling one’. (Fullan, 2007, p.155). Interviews for principals can help to show their understanding of this reform, deployment of resources, and perceptions on barriers and

challenges in this reform. This also indicates the influence on teachers planned and practised curriculum with the process evaluation.

RQ2b and RQ2c aim at teachers' perceptions of this reform and effects on teachers' work and role in the teaching and learning process. The process evaluation aims to check if teachers are implementing the school-based curriculum and planned activities efficiently (Stufflebeam, 2003). However, evaluation with teachers means from a situation with 'multifaceted diversity, overload, and limits to reform' (Fullan, 2007). This means that teachers' teaching plans are usually not entirely determined by their own perceptions. Thus, it is necessary to evaluate the coherence of curriculum implementation between the planned curriculum and practice curriculum. A scheduled semi-structured interview is developed to explore teachers' perceptions of the new curriculum and strategies, influence on teachers and students, and teacher training. For a nationwide reform in a vast country, a comparison between different regions is necessary to evaluate the consistency of implementation. The rationale of sampling is detailed explained in later sections.

The product evaluation measures the positive and negative outcomes of the reform attained by students (Stufflebeam, 2003). Thiessen (2007) demonstrated that changes happened in the culture of classrooms and schools are shaped by students' learning opportunities and attitudes. Thus, RQ3 corresponds to the attained curriculum. This aims to explore students' attitudes towards science and science curriculum and their future expectations to figure out attained changes in their culture. Also, comparative evaluation is used to investigate differences between regions.

3.2.4 *Timeline*

The timeline with key events in this research is shown in the Table below.

Table 3.1

Timeline for the sequence of data collection

Time	Intended curriculum	Implemented curriculum	Attained curriculum
2017	Analysis of old and new curriculum documents		
October 2018		Interviews with teachers in Tianjin	

2019	Analysis of old and new textbooks		
January 2019			Students' questionnaire
March/April 2019		Interviews with teachers in Chongqing and Zhejiang	
Sept/Oct 2019		Interviews with principles in Tianjin and Zhejiang	
January 2020	Analysis of policy documents		

In the following sections of this chapter, detailed evaluation strategies are described at three levels, which contain sampling, data collection methods, data analysis strategies, and a pilot study exploring reliability, validity and ethical issues.

3.3 Intended curriculum

3.3.1 *Overview of evaluation strategies*

As discussed in the Literature Review Chapter, curriculum reforms in China abide by a top-down policy-based approach. The Ministry of Education (MOE) guides reform progress at the central level, although local Teaching and Research Offices make limited adjustments (Ross & Wang, 2011). The fundamental policy has become the first impetus for reform, and teaching and research office has comprehensively studied the new curriculum standards to formulate specific reform plans to meet the requirements of the central policy. At the same time, these policy documents provide guidance and training for teachers following the new textbooks. Therefore, three series of data need analysis: national policy documents, curriculum standards, and textbooks (shown in Table 3.2). Documentary analysis as a qualitative method used in the evaluation of policy documents. Comparative evaluation is for the curriculum standards and textbooks between old and new curriculum.

Table 3.2

Data collected for the intended curriculum evaluation

Content	Issue date	Brief description
National policy documents and interviews with officers	2017-2020	13 official documents issued by the Ministry of Education (MOE) and the State Council 13 official interviews with officers in charge from MOE and the State Council.
General High school curriculum standards	2018	Issued by MOE after the framework of developing core competencies.

		The general curriculum plan leading to subject-based curriculum standards
High school Textbooks	2019	Compulsory course textbooks Optional compulsory course textbooks

3.3.2 *Documentary analysis of educational policies*

As introduced in the introduction chapter, high school education in China is the transitional stage between compulsory basic education and higher education as an upper secondary education. While achieving a large-scale or national reform, government plays a vital role in constructing the social, financial, and political context for the reform (Fullan, 2007). 'Government' in this reform refers to the Ministry of Education (MOE) and the State Council which issued the official policy documents to promote the reform. After documents were issued to the public, responsible officers would be interviewed by reporters and interview transcripts are uploaded for the official website of MOE as an explanation to the released documents. I selected 13 official policy documents from all national documents issued by MOE and the State Council from 2017 to 2020. All selected documents are related to the educational reform in areas of educational development goals, reform guideline, management of teachers and assessment. (Shown in Table 3.3)

Table 3.3

National documents with areas and issue date

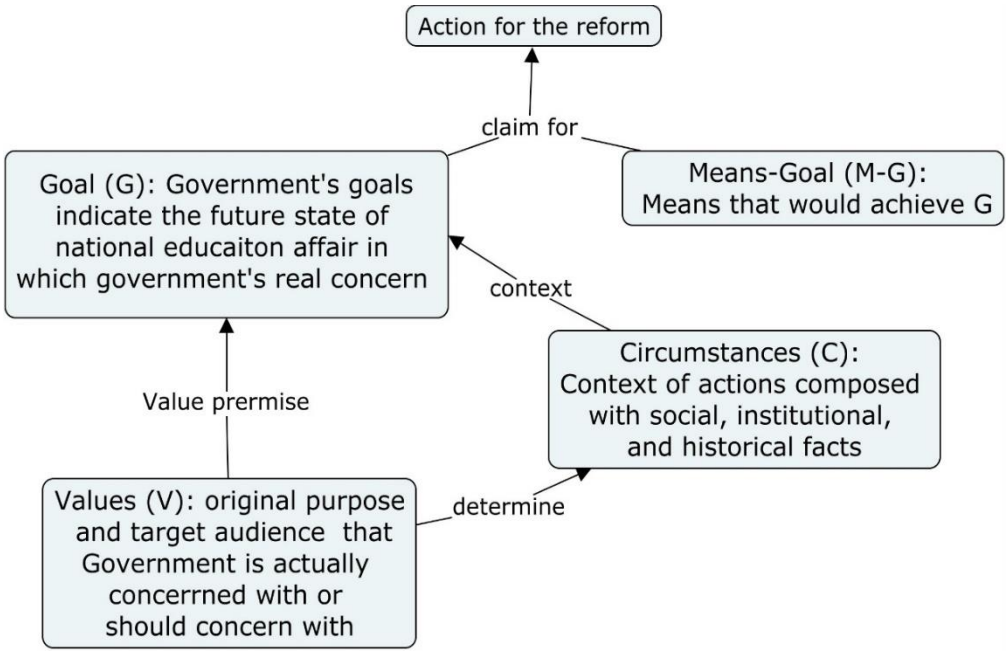
Areas	Name of documents	Issue date
Educational Development Goals	*'Thirteenth Five-Year Plan' for National Education Development*	01/2017
	High School Education Popularization Program (2017-2020)	03/2017
	China Education Modernisation 2035	02/2019
	Implementation plan to accelerate the modernisation of education (2018-2022)	02/2019
	National plan for the construction of textbooks for middle, primary and high schools (2019-2022)	01/2020
Reform Guideline	*Guiding Opinions on Promoting the Educational Reform of General High Schools in the New Era*	06/2019
	Opinions on Deepening the Reform of the Educational Supervision Conductor System in the New Era	02/2020
Teachers Management	*Deepening the Reform and Construction of Teachers in the New Era*	01/2018
	Teacher Education Promotion Action Plan (2018-2022)	02/2018
	Opinions on Strengthening and Improving the Teaching and Research of Basic Education in the New era	11/2019
	Opinions on Strengthening and Improving the Construction of Teachers' Morality in the New Era	
	Opinions on reducing the burden on teachers in primary and secondary schools and further creating a good environment for education and teaching	12/2019
		12/2019
Assessment	*China's College Entrance Examination Evaluation System*	01/2020

In order to answer the RQ1a of the circumstance of the curriculum reform in China, the mechanisms of policy transfer are closely related to the social practices of local education as a discourse practice (Fairclough, 2013). Furthermore, from the review of China's national policy in Section 2.3.1, China has consistently adopted a centrally controlled curriculum policy, which is consistent with its long-standing highly centralized management model for curriculum administration (Zheng, 2005). The evaluation of long-term curricula like this requires a framework based on predominant policy values (Addonizio & Kearney, 2012, reviewed in section 3.5.4). Starting from the Context evaluation of the CIPP model, critical policy analysis can explore the origins and processes of policies, as well as distinguish political rhetoric from proclaimed real policies, and the allocation of knowledge, power, and resources.(Diem et al., 2014; Diem & Young, 2017; Flyvbjerg, 1998)

The approach to process the data of selected national policy documents is based on the practical reasoning structure from political discourse analysis (Fairclough & Fairclough, 2013). The focus of practical reasoning structure is a four-fold structure: Values (V), Goal (G), Circumstances (C), and Means-Goal (M-G). The adopted

Figure 3.3

Practical reasoning structure adopted from Fairclough's work



structure is shown in Figure 3.3. Evaluation of these documents should not focus on the surface content and 'throw words and passages into result part' (Bowen, 2009). All selected documents are carefully reviewed and analysed with the structure to carry out the coding and category establishment. The relevance of documents would be established with issues being explored for other phases of evaluation.

First, I preliminarily processed the textual data of the selected policy document according to the four-fold structure of practical reasoning. I organised it into tables, with the original policy text in Chinese. As examples, I translated several well-organized tables into English and include them in Table 3.4, Appendices 4, and 5. The policy tables clearly displayed the goals and corresponding means of the policies, as well as the circumstances and purposes for which they were issued. This way, we can identify the values embodied in this policy document. Secondly, based on these organized policy tables, I summarised the main policy values to explore what goals or target objects are truly cared about and intended to be achieved by national government when issuing policies. Finally, combining specific goals and means, we reviewed the specific measures and actions of the curriculum reform while using the values as a guiding framework for evaluating and analysing policy texts.

Table 3.4

Summary of 'Thirteenth Five-year Plan' for National Education Development

Information		**Circumstances**	**Value**
Name	'Thirteenth Five-Year Plan' for National Education Development	1. International competition is becoming fiercer, and reforms are happening in many countries all over the world. 2. Following the development and adjustment of domestic economy, education is facing challenge. 3. Remarkable achievements have been made in China's education reform and development.	• General educational plan for future five years (2017-2022). • 'Enhance morality and foster talents' • Promote educational equity • Persist in reform and innovation • Leadership of Communist Party of China
Approve Date	10/01/2017		
Issue Agent	Ministry of Education		

Goals	**Means-goals**
1. The needs and expectations to educational equity of the people.	(1) Guarantee the coverage and quality level of basic public education services. (2) Improve regional imbalance in poverty areas; Increase investment in rural education and implement rural teacher support plan; Increase the enrolment rate of high school education and pre-school education. (3) Accurate financial assistance for students with financial difficulties;
2. Urgent needs of national economic and social development to improve the educational quality.	(1) Implement quality education and strengthen patriotism education. (2) Focus on teacher training and evaluation (3) Deepening the reform of curriculum teaching and examination enrolment system (4) Improve and perfect education evaluation system and quality monitoring system (5) Promote education informatization
3. The long-term needs of the development of national modernization and educational modernization.	(1) Optimize the structure of educational resources allocation (2) Optimize education system structure (3) Optimize talent training structure

3.3.3 *Comparative analysis with curriculum standards and textbooks*

MOE issued new curriculum standards in 2018 for the new curriculum, and new textbooks were published by People's Education Press in 2019. The main structures of curriculum standards are similar between old and new curricula, which contain *curriculum objectives, curriculum content, teaching suggestions, and assessment* (Ministry of Education, 2003; 2018). Thus, the focus on standards comparative evaluation is three-fold: firstly, it explores changes of the educational objectives between with subject-based core competencies and three-dimension objectives (reviewed in Chapter Two). Second, curriculum standard analysis of two curricula is compared based on cognitive processing (Bloom et al., 1956; Anderson, 2006) to explore changes at content level. The third focus explores the changes in teaching advice and assessment of activities in standards and textbooks.

Table 3.5

The cognitive processing dimension of revised Bloom's taxonomy (Anderson, 2006)

Dimensions	Definition	Examples
Remember	The student can recall or remember the information	Define, duplicate, list, memorise, recall, repeat, reproduce state
Understand	The student can explain ideas or concepts.	Classify, describe, discuss, explain, identify, locate, recognise, report, select, translate, paraphrase
Apply	The student can use the information in a new way.	Choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write
Analyse	The student can distinguish between the different parts.	Appraise, compare, contrast, criticise, differentiate, discriminate, distinguish, examine, experiment, question, test
Evaluate	The student can justify a stand or decision.	Appraise, argue, defend, judge, select, support, value, evaluate
Create	The student can create new product or point of view.	Assemble, construct, create, design, develop, formulate, write

3.4 Implemented Curriculum

The aims of evaluating the implemented curriculum are two-fold: to figure out how the curriculum reform is implemented at school and teacher levels in nationwide China. China is a vast country with a large population. Thus, the evaluation of a national reform is complicated to achieve, because the progress of reform in different regions of China is not synchronised, and the imbalance of resources in regions have effects on the implementation. I decided to use open

interviews with school principals at school level and semi-structured teacher interviews in three regions of China: Tianjin, Zhejiang, and Chongqing. The sampling strategy is elaborated in the following section. Furthermore, two interview instruments and analysis strategies are constructed and discussed. Finally, ethical issues are discussed in this section.

3.4.1 *Sampling strategies*

Interviewing as a qualitative approach needs well-designed questions and careful preparation (Coe, 2017). Sampling is a significant component in conducting interviews to evaluate the implemented curriculum. Sampling strategies used are two-fold: regional and participant sampling. Because the purpose of the research is 'depth not breadth', 'information rich cases' should be selected (Patten, 2015).

Regional sampling

The geographical map of China is shown in

Figure 3.4 and three selected regions are circled out. The reasons three regions were selected to evaluate the curriculum reform are:

1) Three regions are located in three large areas of China: Tianjin-North; Zhejiang-Southwest; Chongqing-Southeast and three regions are typical in each area.

2) Reform progress in these regions occurred out of synch. Zhejiang province implemented in 2017, followed by Tianjin in 2018 then Chongqing in 2019.

3) There are cultural and social differences between three regions, as explained below.

Figure 3.4

Map of China with selected regions circled out

Tianjin

Tianjin is a municipality in northern China, which has about 15 million residents in 16 districts (6 urban districts and 10 rural districts) and 56000 candidates for Gaokao (data in 2019).

Zhejiang

Zhejiang is a province in south-eastern China with about 57 million residents and 306, 000 candidates (data in 2019).

Chongqing

Chongqing is a municipality in south-western China with about 30 million residents and 264,000 candidates (data 2019).

Participant sampling

Four science teachers in Tianjin, three in Chongqing, and twelve in Zhejiang were selected for interviews. Teachers in Tianjin and Chongqing are from rural and urban schools. Because of

the vast of Zhejiang province, teachers were selected from senior secondary schools in three cities: Hangzhou (provincial capital), Xinchang, and Wenzhou. Table 3.6 below shows the detailed characteristics of selected teachers and schools.

Table 3.6

Teacher and school characteristics

Teacher label	Gender	Subject	Years in teaching	Grade
T1	Male	Biology	12	3
T2	Male	Technology	15	2
T3	Male	Physics	4	1
T4	Female	Chemistry	3	1
C1	Male	Physics	10	2
C2	Male	Physics	9	2
C3	Female	Chemistry	10	1
Z1	Female	Physics	13	1
Z2	Male	Chemistry	18	2
Z3	Male	Physics	27	1
Z4	Male	Physics	7	2
Z5	Male	Physics	3	1
Z6	Female	Physics	27	1
Z7	Male	Physics	19	1
Z8	Female	Chemistry	2	1
Z9	Female	Biology	16	3
Z10	Female	Chemistry	11	3
Z11	Female	Chemistry	20	3
Z12	Male	Physics	21	1

T: Tianjin, C: Chongqing, Z: Zhejiang

3.4.2 ***Principal interview***

The interviewees were from three schools in the selected areas. A principal in a high school in China plays a vital role in the management of teachers and dealing with educational changes. Table 3.7 below shows the basic information of three principals.

Table 3.7

Principals' basic information

	Location	Age	Gender	Subject	School information
Principal A	Tianjin	43	Male	Geography	High school in rural Tianjin
Principal B	Xinchang, Zhejiang	40	Male	Physics	High school with the best student outcomes in Xinchang city.
Principal C	Wenzhou/ Hangzhou, Zhejiang	38	Male	Physics	High school in Wenzhou, Zhejiang.

Open interviews were conducted to explore changes in school-based curriculum level in this reform. Questions explore two aspects: school-based curriculum in the reform and comments on the new curriculum. The detailed protocol for principal interviews is shown in Table 3.8 below.

Table 3.8

Outline of interview with school principals

Questions	Aspects
Would you please briefly introduce your school-based curriculum? What sorts of difficulties would you expect to come up in the first year of implementation? What kinds of training have been or will be provided for schools to promote implementation of the new curriculum? What function does the school-based curriculum have in promote the implementation of the new curriculum?	school-based curriculum and the new curriculum
What do you consider as the distinctive features of the new curriculum when compared with the old one? What issues do you think would encounter in the implementation process of the new curriculum? How confident are you that the new curriculum will turn out to be a success?	Comments on the new curriculum

For the first aspect, questions focus on the functions of the school-based curriculum in this reform and management of teachers and students. These questions allow principals to introduce and further discuss their school's characteristics relating to teacher management and/or class teaching during this curriculum reform at school level. For the second aspect, these questions invite critical comments on the new curriculum, which allows principals to freely express their opinions and address other issues or examples they concerned with.

Each school principal received a formal letter to seek their permission to conduct the interview (see in Appendix 1). All interviews were conducted in Chinese and recorded with the permission of principals. All interview transcripts were translated into English for citing in this thesis, which also received their acknowledgement and permission after sending the transcript to them.

3.4.3 *Teacher Interview*

19 teachers participated with the interview. Four teachers in Tianjin were interviewed in October 2018 when the new curriculum was implemented in high schools. Three teachers in

Chongqing were interviewed in October 2019 when they had not officially implemented the new curriculum. Twelve teachers in Zhejiang were interviewed in March 2019 when they had implemented the new curriculum for three years and the first round of students had attended the College Entrance Examination (known as 'Gaokao'). The imbalance of progress in three regions may indicate teachers' experiences of the national curriculum reform. To elicit interviews' feedback of the reform, a procedure was followed including preparation of interviewers and interviewees, interview, and record with transcripts. The semi-structured interview procedures and actions are shown in Table 3.9 and Table 3.10 below.

Table 3.9

Teacher interview procedure

Procedure	Action
Preparation of interviewer	Acquire teachers' teaching or lesson plan before and after the curriculum reform to find out the differences in literature.
Preparation of interviewee	Participants would be given some concepts about curriculum changes to prepare some evidence to show the actual changes in class teaching. (For example, the use of practical work in new curriculum, new group study methods, how to arrange teaching progress, students' interest in Science)
Interview	Interview questions consist of the teaching plan study and pre-given concepts. In addition, further questions would focus on teachers' attitude towards the new curriculum and curriculum reform.
Summary	Transcript teachers' answer and evidence shown in the interview combining with teaching plans.

Table 3.10

Outline of semi-structure interview with teachers

Questions	Aspects
1. What are the specific changes in the new curriculum reform? 2. In what ways does the new curriculum policy affect teachers' work? 3. What are the effects of the new curriculum policy on student learning? 4. Did you implement the targeted teaching strategy or curriculum design corresponding to the new curriculum policy? If so, what are the specific aspects? 5. What are the changes in students' attitudes towards science learning during the implementation of the new policy?	Understanding of the new curriculum and science learning
1. What should be the core of the current new science (physics, chemistry or biology) course (or future science course)? 2. What are the main characteristics that distinguish this reform from past reforms? In which specific aspects is the most obvious? 3. What is the most important for students in science learning at this stage?	Teaching practices & students' attitudes
1. What are the main factors affecting science teaching or curriculum	Consideration of

design during the reform process? 2. What difficulties might be encountered in the future teaching of science subjects? 3. Do you think the role of teachers will change in future teaching and learning relationships? If so, what are the specific aspects? 4. Do you think the role of students will change in future teaching and learning relationships? If so, what are the specific aspects?	factors may affect implementation
1. Has any specific training been conducted or ongoing on new reforms? 2. Is the content of the training about the level of policy theory or practical teaching 3. Are the trainings helpful? In what ways do they help teachers?	Teacher support

Each interview lasted about 30 minutes with four aspects of questions including understanding of the new curriculum with their experience in teaching, attitudes towards the changes in science curriculum development and roles in future classroom teaching, and to what extent they received support from schools and government. The interview outline is shown in Table below. As mentioned in the interview procedure protocol, teachers were encouraged to address their experience by raising specific examples to elaborate the detailed changes in daily classroom teaching.

Three teachers were interviewed for a pilot study to test if the interview questions were proper and clear for understanding. After discussion with them, seldom adjustments were necessary, and most questions' meaning were clear for them. All interviews were collected by radio tapes which were transcribed. For validity of the semi-structured interview study, transcripts were sent back to the interviews to ensure the comments they given clarified what they thought.

3.4.4 *Analysis of interview data*

Interview data are complex and beyond the metaphor of 'transparent windows to each other's thinking, and souls and hearts and minds' (Flick, 2014). Hence, theoretical analysis method and process require steps of working with quantitative interview data. The following sections introduce and elaborate these steps including data preparation, theoretical methods, and analysis process in the qualitative semi-structured interview study.

Preparation of interview data

The first step of data preparation before analysis is to transcribe the interview tapes. A detailed transcription with thoughtful punctuation can be helpful for data analysis and interpretation if the

interview was recorded months ago (Seidman, 2006). Furthermore, interviews were conducted in Chinese, although results including excerpts need to report in English with translation. As Roulston (2014) demonstrated, there are no standard approaches to transcribe or translate interview data, but the practical process depends on consideration of the types of objectives and analytic questions.

Thematic analysis method

The second step of data analysis reduces, reorganises, and represents interview data. As interview data contains large amounts of text, reduction of data is significant for data analysis and interpretation, which this step can be done 'inductively rather than deductively' (Seidman, 2006, p. 117). In this study, thematic analysis is used as data reduction method. As a 'poorly demarcated and widely used' method used in qualitative data analysis, thematic analysis is 'a method of identifying, analysing and reporting patterns (themes) within data' (Braun & Clarke, 2006). Braun and Clark (2006) outlined six phases of thematic analysis and table below shows the phases and description of practical process in this study (shown in Table 3.11).

Table 3.11

practical process in thematic analysis adopted from Braun and Clarke's work (2006)

Phase	Description of practical process in this study
1. Data Familiarisation	Transcription, reading and re-reading the data, punctuation of ideas.
2. Initial coding	Coding all interested features and reducing data to locate the interest.
3. Searching for themes	Trying to organize codes into potential themes and gather all these themes to categories.
4. Reviewing themes	Checking and classifying themes to ensure the themes work with all data and generating a thematic map with categories and themes.
5. Defining and naming themes	Define each category and themes with clear definition and names.
6. Producing the report	Selection of examples or stories and comparing categories and themes between interested features. Producing the analysis report.

As introduced in sections above, I conducted in-depth interviews with principals and teachers from schools in different regions in China. The interviews were semi structured and conducted by me in Chinese. Interview participants were informed the interview process and allowed to audiotape the interviews. The interview audio files were transcribed into text and through repeated

reading, meanings and patterns are sought in the textual data to form an overall impression of each teacher and principal interview. Principal interviews tend to be more fragmented compared to teacher interviews, as teachers typically answered questions in sequential order while principals expand upon aspects that interest them personally. All transcripts were collated into *Microsoft Office Word 2019*. Quotations from participants in these interviews have only been revised for the purposes of clarity. For validity of the semi-structured interview study, transcripts were sent back to the participants to ensure that the comments they given clarified what they thought.

On the basis of being familiar with the interview text and identifying relevant words and sentences, the first phase of coding was to progress through a series of incremental steps, from the original text to researching the problem, with each step building upon the previous one (Auerbach & Silverstein, 2003). The content of these codes should adhere to several basic principles: 1) contribute to answering research questions; 2) repeatedly mentioned by interviewees during the interviews; 3) emphasized by certain interviewees; 4) mentioned by interviewees even if not directly related to the interview questions. These initial codes used participants' own terms and then grouped to a new set of codes. The analysis of the transcripts allowed me to refine and develop the initial categories for further searching for the themes. Here I use the excerpt (Table 3.12) from a teacher's response to the effect of new curriculum policy on teacher's work to show the analysis of teacher interviews. I chose this as an example because this teacher was very organized when answering, could profoundly point out the problems, and provided a lot of help for sorting out the codes and themes of other teachers' interviews. For example, he not only paid attention to the changes in teaching knowledge content, but also mentioned the issues regarding the professional development of teachers. In this stage of analysis, similar codes were grouped to initial themes and repeated for all interview data.

Table 3.12

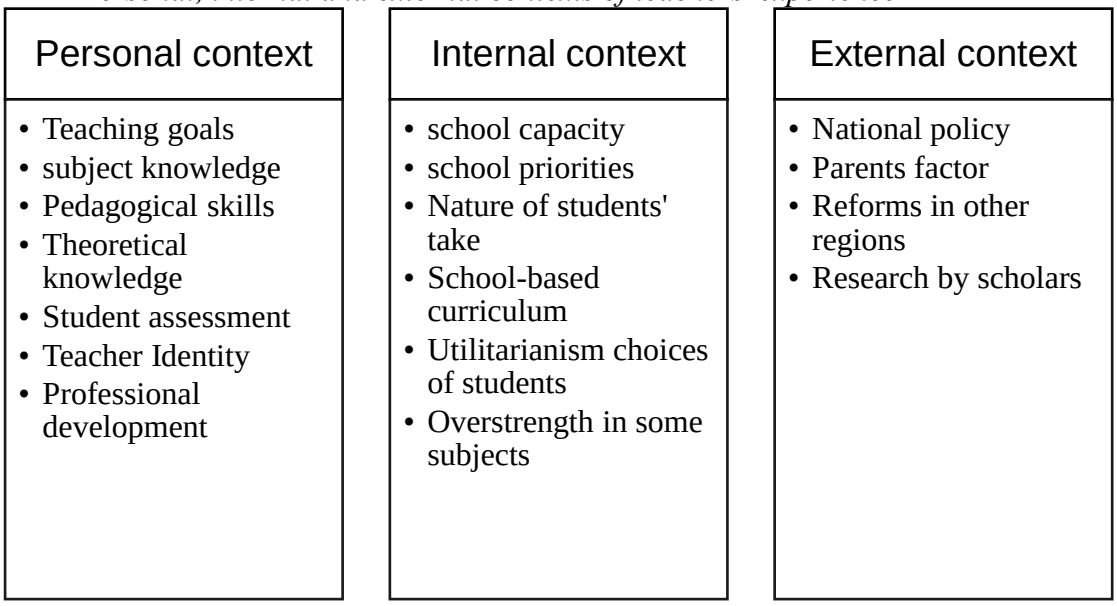
Excerpt of teacher's response to the effect of new curriculum policy on teacher's work

Interview Data	Initial codes	Grouped codes/Initial themes
Q: In what ways does the new curriculum policy affect teachers' work?		
C2: I believe there are two main effects of teachers' work. Firstly, there are many updates on subject contents which make many old teachers have significant difficulty in receiving new subject contents. In the other hand, the progress of teaching arrangement has been significantly delayed because of changes on the date of assessment. These changes cause many teachers, including me, to get used to the traditional teaching style and have a strong resistance to the new curriculum reform. We may need more time to get used to it.	'Updates on subject contents' 'Old teachers have significant difficulty' 'Teaching arrangement have been significantly delayed' 'Date of assessment' 'Traditional teaching style' 'Strong resistance' 'More time to get used to'	Subject knowledge Professional development Pedagogical skills Student assessment

As the content emphasis of the interview responses of three school principals varies greatly, I regard the themes of the principal interviews as three cases for sorting out. While the teacher's responses were in line with the framework of semi-structured interviews, therefore, for teacher interviews, it is necessary to repeatedly refine group codes and initial themes until they are concise enough yet comprehensive enough to encompass all interview content, in preparation for the subsequent report. Through the process of analysing the interview contents and utilizing Goodson's framework (2003), the personal, internal and external context that influence teachers' responses to the curriculum reform were identified in Figure 3.5.

Figure 3.5

Personal, internal and external contexts of teachers' experience



Based on the contexts and initial themes summarised in the previous stage, the final themes of teacher interviews were determined align with research questions in section 5.4. These themes served as the basis for reporting and presenting findings, which were further elaborated upon in the beginning of the subsequent data analysis section. By combining interview transcripts with the background of the interviewees, select relevant examples that align with the themes and express them in a concise, clear, and logical manner to retell the participant's story.

In short, by analysing the interview texts and the backgrounds of the interviewees, I gained a deep understanding of their unique life experiences. By combining these two elements, identified significant moments or events that have shaped their lives and influenced their thoughts.(Seidman,

2006) To provide examples of each participant's story, I carefully selected relevant and representative cases. These cases should effectively convey what they have experienced while maintaining clarity and coherence. Furthermore, in this process, it is crucial to maintain a relative objectivity. Rather than expressing one's own viewpoint, the focus should be on providing a more comprehensive presentation of the interviewee's perspectives. Therefore, careful evaluation and discussion of the characteristics of the interviewees themselves are also necessary.

3.4.5 *Ethical considerations*

This study follows British Educational Research Association (BERA, 2018) ethical guidelines. An email with completed ethics forms was sent to the Ethics Sub-Committee of School of Education in Durham University. An ethical approval was received in 2017, which can be found in the Appendix 1: Ethics related documents. In this study, principals and teachers' interviews personal record data were collected for analysis. Therefore, they have rights to fully understand the research intentions and withdraw the research. All participated schools, principals, teachers, and students are anonymous and are substitute by letters or numbers.

Informed consent obtained. Before data collection, all participants received an email with the informed consent letter (see Appendix 1.4: Declaration of Informed Consent) which briefly introduced the intentions of this study, data collection methods, data protection, and rights to withdraw at any time. All interviewees were volunteers to participate this study and signed the informed consent as permission.

Issues as an evaluator and respect for participants. For qualitative interview study, one of the challenges affecting the evaluation is the evaluator's value with assumptions (Flick, 2014). These assumptions may produce bias in interview and analysis. Therefore, an evaluator should be impartial to all responds of participants and aware own assumptions affecting the evaluation. As a former science teacher, I know it is necessary to show respect to principals and teachers who have much experience on teaching and contact with students. Moreover, as an education researcher, it is also significant to have a objective view to explore what happen with interviewee through in-depth interview.

3.5 Attained Curriculum

3.5.1 *Evaluation strategies*

Data collected at the attained curriculum level aims to explore students' attitudes towards science and science curriculum and future expectation to figure out the attained changes in their culture. Also, comparative evaluation is used to investigate differences between regions. As reviewed in the literature review chapter, science subjects have been vigorously promoted with higher proportion in secondary education than other subjects since 1978. Whereas the new curriculum emphasises to cultivate students' core competencies which encourage teenagers to choose their subjects depending on interests and future professional plans. Therefore, science-related attitudes were chosen as indicators at attained curriculum level.

This study focuses on students' science-related attitudes for these reasons:

1) there are regular examinations in schools to test students' competencies like scientific concepts and application, however, there is not systematic measurement for students' science-related attitudes.

2) attitude includes 'cognitive, affective and behavioural' components' (Krech, 1962), and some researchers argued that these components should be threated individually and narrowed down to 'attitude object' (Crano & Prislin, 2006). Specifically, attitudes towards science may have influences on enthusiasm and involvement in learning science. For example, negative attitudes to science, like considering science learning as a very difficult process that only suits for genius, may prevent their future study in science field, and even scare or hate to learn science. Therefore, measuring science-related attitudes in various aspects show significance in evaluation of the new curriculum.

3) in the new curriculum, students would have more autonomy in choosing subjects, thus, attitudes to science may affect their future choice in subjects.

In this study, performance of content knowledge is not used as a parameter. The reasons are two-fold: 1) the national reform is at its early implementation period and most teaching practice of content knowledge is still in exploration. 2) the new textbooks were published and used in summer 2019, thus, it is difficult to construct measurement with valid comparison with the old

curriculum.

The attitude scale used in this study is a five-point Likert-type scale adapted from the attitudes towards science scales developed by Kind (2007). The original scales include seven aspects related to science to measure 'learning science in school, practical work in science, science outside of school, importance of science, self-concept in science, future participation in science, and attitude to school' (Kind, 2007, p. 12). This study focuses on attitudes towards science activities, importance of science, self-concept, and future participant in science. The modified statements were discussed in the data collection section and can be found in Appendix 2: Modified statements of attitude scale.

Furthermore, to explore students' experiences for changes in the new curriculum implementation, semi-structured group interviews were conducted for a small group of students. These interviews were conducted by teachers and recorded by tape. This can be helpful in data triangulation of teacher interviews and student questionnaires. Detailed interview protocol is provided in Sub-section.

3.5.2 *Sampling for the student questionnaires*

Students in the questionnaires and interviews are from class taught by teachers participated in teacher interviews. All participants were volunteers in three curriculum groups from three classes (two grade-one class and one grade-two class) in one secondary school in Tianjin. The timing of the questionnaires was in January 2019. Standard instruments are used in this study for measuring science-related attitudes introduced in next section.

As questionnaires were conducted using online survey system and students volunteered to attend this study, some students dropped out from this study. This may because some students rose to the last year of high school and had to pay much attention on preparing the examination. Therefore, to further explore students' attitudes and experiences with the new curriculum, focus groups of students were selected for group interviews host by their class teachers. The amount and distribution of students and teachers involved is shown in Table 3.13.

Table 3.13

Samples of student questionnaires

Grade / Gender	Male	Female	Total
Grade one	74	78	152
Grade two	30	33	63
Total	104	111	215

T: Tianjin, C: Chongqing, Z: Zhejiang.

3.5.3 *Collection methods*

Due to geographical difficulty in collect paper questionnaires, online survey system is used in this study for data collection. Online questionnaires were sent by class teachers and received within one week. The scale for measuring science-related attitudes has six aspects: learning science in school, practical work in science, science outside of school, importance of science, self-concept in science, future participation in science. Statements of these indicators were adopted from Kind's (2007) research and slightly modified to meet the specific circumstance in China. Each statement has a five-point Likert response and was coded as the responses were coded as *'Strongly agree' = 5, 'Agree' = 4, 'Neither agree nor disagree' = 3, 'Disagree' = 2, and 'Strongly disagree' = 1*. These statements were elaborated in the following paragraphs.

There are seven factors in original scale of measurement:

1. *Learning science in school*
2. *Practical work in science*
3. *Science outside of school*
4. *Importance of science*
5. *Self-concept in science*
6. *Future participation in science*
7. *Attitude to school*

This study aims to evaluate attained curriculum with students' science-related attitudes. After discussion with teachers and principals, it is sensitive topic that students comment their schools. Therefore, the last factor 'attitude to school' is removed from the attitude scale in this study. Also, factors 1, 4, 5, and 6 are fully adopted from kind's scale (2007). Detailed changes of statements in factors 2 and 3 were described in turn.

Practical work in science

The original scale includes eight statements:

1. *Practical work in science is exciting.*
2. *I like science practical work because you don't know what will happen.*
3. *Practical work in science is good because I can work with my friends.*
4. *I like practical work in science because I can decide what to do myself.*
5. *I would like more practical work in my science lessons.*
6. *We learn science better when we do practical work.*
7. *I look forward to doing science practicals.*
8. *Practical work in science is boring.*

Practical work in science class in China normally stand for two activities: demonstration experiments and group experiments in class teaching. The second statement was modified for more explanation to 'I can see the actual results rather than literature description'. This statement refers to the experiments demonstrated by teachers. The fourth statement was amended as 'I can do it by myself rather than teachers' demonstration. This refers to the group experiment and make its meaning clear with the demonstration experiment. The revised scale in this study is:

1. *Practical work in science is exciting.*
2. *I like science practical work because I can see the actual results rather than literature description.*
3. *Practical work in science is good because I can work with my friends.*
4. *I like practical work in science because I can do it by myself rather than teachers' demonstration.*
5. *I would like more practical work in my science lessons.*
6. *We learn science better when we do practical work.*
7. *I look forward to doing science practical.*
8. *Practical work in science is boring.*

Science outside of school

The original scale has six statements:

1. *I would like to join a science club.*
2. *I like watching science programmes on TV.*
3. *I like to visit science museums.*

4. *I would like to do more science activities outside school.*
5. *I like reading science magazines and books.*
6. *It is exciting to learn about new things happening in science*

In the first statement, via translation, 'science club' is not usual used in Chinese, thus, it was amended as 'science interest group' for students who are interested in science or technology. Also, students may use computer or mobile phone to watch TV programmes, therefore, 'online' was added to the second statement. The modified scale in this study is:

1. *I would like to join a science interest group.*
2. *I like watching science programmes on TV or online.*
3. *I like to visit science museums.*
4. *I would like to do more science activities outside school.*
5. *I like reading science magazines and books.*
6. *It is exciting to learn about new things happening in science*

3.5.4 *Pilot test for student questionnaire*

The science-related scale was pilot tested in September 2018 before the pre-test in January 2019. A class of high school students in Tianjin completed the online questionnaire. 35 questionnaires were collected, and students spend about 10 minutes to finish the questionnaire. Therefore, this questionnaire would not make students difficult to finish. The detail of the pilot sample is as in Table 3.14.

Table 3.14

Sample for pilot test

Gender	Number of participants
Male	19
Female	16
Total	35

Data collected from the pilot test were analysed through SPSS to check the internal consistency. Answers to negative statements was adjusted while data entry. Cronbach's alpha for science-related attitudes in six aspects can be found in Table 3.15.

Table 3.15

Cronbach's alpha for science-related attitudes

Aspects	Cronbach's alpha
Leaning science in school (6 items)	0.73
Self-concept in science (7 items)	0.74
Practical work in science (8 items)	0.79
Science outside of school (6 items)	0.89
Future participation (5 items)	0.86
Importance of science (6 items)	0.79

For all internal consistency was tested above 0.7, it indicates that all scales can be used for further study. However, the reliability of 'Learning science in school' and 'Self-concept in science' are the lowest in the scale. This may indicate that some statements still need improvements and have more modified in translation into Chinese. Therefore, I have discussed these statements with colleagues in translation and teachers to make sure the translation in Chinese have little misunderstanding.

3.5.5 ***Focus group student interviews***

Sampling

A small group sample was chosen from each class as focus group interview. Sampling follows two principles:

1) Each participant for interviews is volunteer and informed the purpose of this study and interview protocol. Also, they have right to withdraw whenever they are willing to.

2) Each student is selected by their class teacher. Teachers were asked to choose students at different performance levels. Number of participants should be 4 to 6 persons.

Data collection procedure

The interviews were conducted after the post-test of student questionnaire. The group interview was hosted by the class teacher in March 2020. Because of effects from the Covid-19 pandemic, interviews were conducted with online meeting by software in computer or App in Mobile. Before the interview, students would receive a digital document with the interview questions and were informed with the purpose of this study. During the interview, the class teacher is in charge of raising questions and make sure everyone expresses their opinions, while students are free to either express their own opinions or comment on others' viewpoint. Interview was tape

recorded, which have received permission from participants (see Appendix 1).

The questions in group interviews are guided by the interview protocol from four aspects in order to explore more detailed experiences on the new curriculum and changes in their real life. The interview protocol is shown in Table 3.16.

Table 3.16

Student interview protocol

Aspects	Questions
Comments and experience on the new class teaching patten.	1) Please share some experiences or stories about the new class teaching patten. 2) Please summary the advantages and disadvantages of the new pattern. 3) Please compare with the old and new pattern. The responds are not limited in questions above. Answers can be short or personal.
Comments and experiences on selecting subjects	1) Please talk about the understanding of the traditional subject selection. 2) Does the new curriculum make more choices for you? 3) Please raise your difficulties while selecting subjects. 4) What factors affects you most during selecting subjects?
Comments on science learning and subjects	1) Do you choose science subjects? 2) Please state your reasons for choosing or not choosing them. 3) What do you think of the importance of science in high school learning?
Future plan	1) Do you have plan for future career? 2) Would you please share your plan with others?

The first three aspects mostly aim to explore more experiences and stories in students' real life. Comments on the changes of the new curriculum attained by students can indicate their feeling about the reform. The last aspect of questions encourages students to see themselves in the curriculum and future career plan. During the interview, the class teacher tends to encourage students to share their perceptions on curriculum, reform and feelings attained in class. They have shown clear viewpoints and tried to express by their own words. The discussion between them is also positive and they can complement each other.

3.6 Summary

In this chapter, the evaluation framework as guideline of this study and data collection methods were elaborated for evaluating the new curriculum reform in China at different curriculum

levels.

A mix-method approach was employed in this study to better explore and evaluate the reform and collect feedback from principals, teachers, and students who have experienced this reform at different levels. For the intended curriculum, qualitative documentary analysis of official documents, curriculum standards, and textbooks could raise a context of this reform and establish a theoretical foundation for further evaluation. For the implemented curriculum, perceptions of principals and teachers come to be vital for evaluation. Thus, interviews and thematic analysis can elicit their in-depth beliefs and attitudes. For the attained curriculum, students' attitudes and experience are as evidence to reflect the reform. Quantitative questionnaire data and qualitative interview data have validity to concrete what students is experiencing and explain the influence at the student level. In the next chapters, findings of evaluation at three curriculum levels are reported to answer the research questions.

Chapter 4 Data Analysis of intended curriculum

4.1 Overview

This chapter aims to answer the first research question and its sub-questions at the intended curriculum level with analysis of policy documents, curriculum standards, and textbooks.

Research Question 1: What is the context of this national curriculum reform and what are the similarities and differences between the old and new curriculum?

Sub-questions:

RQ1a: What context is the new curriculum taking place?

RQ1b: How does curriculum standard translate the official policy documents?

RQ1c: In what ways is the new curriculum distinct with the old one?

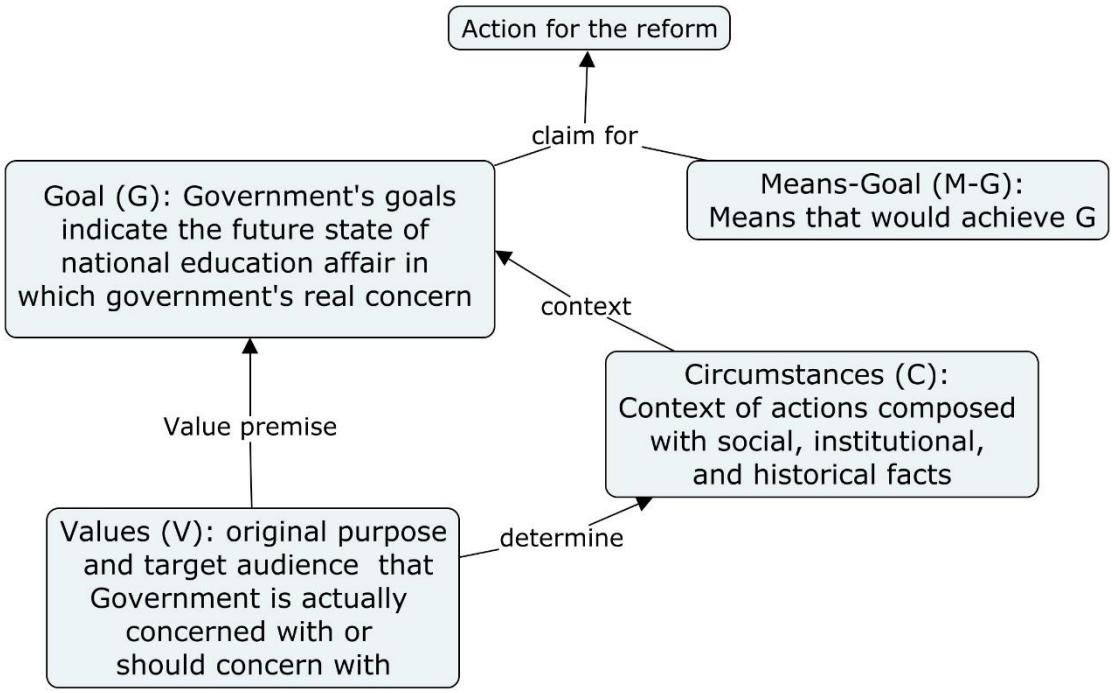
Findings are reported from three sections at three sub-levels of the intended curriculum: documented curriculum, standard curriculum, and textbook curriculum, which are described in last chapter. Documentary analysis would demonstrate the context of this reform from a national perspective while both curriculum standards and textbooks were comparative discussed to explore the changes and reasons behind them.

4.2 The Documented curriculum

As described in the Methodology chapter, the findings are presented from the thirteen selected national policy documents (shown in Table 4.1) issued by MOE and the State Council. First, descriptive summaries with the practical reasoning structure (Fairclough & Fairclough, 2013) are presented in a series of tables (shown in Appendix). Second, findings of these documents are analysed with a set of themes and coding process. Third, timeline and context of this reform is presented with excerpts and critical analysis.

Figure 4.1

Practical reasoning structure adopted from Fairclough's work (2013)



In critical reflecting these policy documents in this reform from 2017 to 2020, findings were reported from values in specific themes with excerpts or summary of documents. This aims to describe the political context of this reform and support further discussions of the intended curriculum.

Table 4.1

Selected National documents with areas an issue date

Areas	Name of documents	Issue date
Educational Development Goals	*1. 'Thirteenth Five-Year Plan' for National Education Development*	01/2017
	2. High School Education Popularisation Program (2017-2020)	03/2017
	3. China Education Modernisation 2035	02/2019
	4. Implementation plan to accelerate the modernisation of education (2018-2022)	02/2019
	5. National plan for the construction of textbooks for middle, primary, and high schools (2019-2022)	01/2020
Reform Guideline	*1. Guiding Opinions on Promoting the Educational Reform of General High Schools in the New Era*	06/2019
	2. Opinions on Deepening the Reform of the Educational Supervision Conductor System in the New Era	02/2020
Teachers Management	*1. Deepening the Reform and Construction of Teachers in the New Era*	01/2018
	2. Teacher Education Promotion Action Plan (2018-2022)	02/2018
	3. Opinions on Strengthening and Improving the Teaching and Research of Basic Education in the New era	11/2019
	4. Opinions on Strengthening and Improving the Construction of Teachers' Morality in the New Era	
	5. Opinions on reducing the burden on teachers in primary and secondary schools and further creating a good environment for education and teaching	12/2019 12/2019
Assessment	*China's College Entrance Examination Evaluation System*	01/2020

4.2.1 *Context of this reform*

Educational policy concerned in this study is public education policy which is formulated by various means on behalf of the country or central government to control the behaviour of individuals or organizations (teachers, students, or schools). As the government has to formulate policies in an effort to effectively respond to the public's needs, education policy would become a tool to manage public expectations for education.

As reviewed in the Literature review Chapter, since the 'economic reform and open up' in 1978, various reform measures are frequently introduced in the field of education, and most of these reform measures appear as policies. Policy makers claimed actions to achieve expected goals which is increasingly emergency, however, they have distance with principals, teachers, parents, and students who were excluded from the policy making system. Thus, educational policies in local level for implementation in practice need to have adjustment for adaption to local circumstances. Furthermore, while many people expect new policies to influence the practice, others believe that these policies are not important and do not need to change the status quo. Policy makers often encourage stakeholders to participate in the educational policy making process, however the forms and ways of participation are limited. Due to the political limit and bureaucratic agenda, the actual influence from the participants to the final policy text is unclear. As a key component in a reform, principals need to follow the value of the central Government, even if there are conflict between the policy and their practice. Therefore, there have tense between the expectations from national policy, local policy, principals, teachers, and students.

The circumstance of the educational policy in China demonstrates that:

1) Educational policy in China is not only the Government's response to the public demand with the improvement of education quality, but also the compromise between the central and local Government. These drive the central Government to assign short-term (e.g. *High School Education Popularisation Program 2017-2020*), mid-term (e.g. *'Thirteenth Five-Year Plan' for National Education Development*), and long-term (e.g. *China*

Education Modernisation 2035) national plan to guide actions in educational reform. These documents can constitute China's policy structure and ensure the control of the central Government. The State Council and Ministry of Education would also issue policies for teachers (e.g., *Deepening the Reform and Construction of Teachers in the New Era*) and textbooks (e.g., *National plan for the construction of textbooks for middle, primary, and high schools*).

2) Educational policy in China involves a specific set of values which have connection with many social and political values. Compared with other public policy areas, in addition to the distribution of a large number of material resources, there are also more policies for the distribution of value resources in the education field, such as social morality and patriotic spirit.

In 2019, '*Guiding Opinions on Promoting the Educational Reform of General High Schools in the New Era'* claimed to deepen the curriculum reform and develop the morality education in the new curriculum. This reform raised a core value that is to achieve the goal of "enhance morality and foster talents". The following excerpt is a typical example showing the importance of morality education in this reform.

Insist on integrating 'enhance morality and foster talents' into ideological and morality education, cultural knowledge education and social practice education. In-depth development of Xi Jinping's ideological education on socialism with Chinese characteristics in the new era, strengthening education on ideals and beliefs, guiding students to establish a correct outlook on the country, history, nationality, and culture, and planting the ideology of loving the party, patriotism, and the people, and determined to listen to the party's order and follow up the party goes and establishes the lofty aspiration to study hard for the great renewal of the Chinese nation. Actively nurture and practice the core values of socialism, carry out in-depth education on Chinese excellent traditional culture, strengthen student moral education, and help students develop good personal morality and social morality. It is necessary to formulate an implementation plan for moral education work in accordance with the actual situation, highlight the key position of ideological and political courses, give full play to the moral education functions of various disciplines, and actively carry out party and group organization activities and theme education, ritual education,

practical education and other activities.

3) China is facing challenge and opportunities in worldwide competition, which can be seen as the 'new era' for China. Following excerpts from documents can show its meaning.

During the 'Thirteenth Five-Year Plan' period, China's development is still in a period of important strategic opportunities that can make great achievements, and it is also facing severe challenges of overlapping contradictions and increasing hidden risks. Effectively responding to various risks and challenges, and constantly opening up and developing new realms, have put forward unprecedented new tasks and new requirements for the realization of education modernization. ('Thirteenth Five-Year Plan' for National Education Development)

Similar description in response of interview by the Xinhua News Agency

The next five years (2018-2022) will be a historical period of meeting the two hundred-year goals, a key period for implementing the spirit of the 19th National Congress of the Party and the spirit of the National Education Conference and laying the foundation for the realization of the goal of education modernization in 2035. The connection period between the ending of the 'Thirteenth Five-Year Plan' and the start of the 'Fourteenth Five-Year Plan'.

Besides, 'modernisation' is another common word frequently shown in policy documents as a long-term goal for the education development in China.

Socialism with Chinese characteristics has entered a new era, and the basic, leading, and overall status and role of education have become more prominent. Accelerate progress towards an innovative country, build a modern economic system, build a prosperous, strong, democratic, civilized, and harmonious and beautiful socialist modern power, realize the Chinese dream of a great rejuvenation of the Chinese nation, and meet the needs of the people for a better life. We must accelerate the modernization of education and build China into a powerful country in education. (China Education Modernisation 2035)

Thus, policies in this reform have shown two general goals which are both ambitious: one is to cultivate talent people for the great renew of Chinese nation or so-

called modernisation along the path of socialism with Chinese characteristics; the other is to promote the reform of morality education in the new curriculum, which contain views on the country, history, nationality, and culture, and planting the ideology of loving the party, patriotism, and the people.

However, ambitious goals may indicate the limit of the up-to-down policy making process that making the implementation process too ideal to neglect participants' misunderstanding, resistance, and localisation. Furthermore, next section elaborated these documents from their values to have critical view on the ideal curriculum at the intended curriculum level.

4.2.2 *Documentary analysis from four main values*

While reviewing these national policy documents, this section of critical reflection focuses on four main values: 1) Equity, 2) Adequacy, 3) Efficiency, and 4) Choice, which are mentioned in reflections on policy in Michigan (Addonizio & Kearney, 2012). The initial question can be extended to exploring how these policy documents address these values and to what extent have influence at each level in this curriculum reform. Later paragraphs discussed the four values with further specific themes (shown in Table 4.2).

Table 4.2

Four main Values and specific themes

Values	Further specific themes
Equity	Equity between regions
	Equity between schools
	Equity for every student
Adequacy	Adequate resources provided by Government
	Adequate and quality education offered by schools
Efficiency	The role of Government
	Effects on reform implementation
Choice	Choice of school
	Choice of subjects
	Choice at local or school level

Firstly, Equity raises the question of whether the policies for this reform have achieve the fairness to people by adjusting resources between regions and equally

providing essential political to support schools and teachers. As mentioned in Literature review chapter, the Central Government in China tend to play a 'macro-control' role in policy making while local government can have their own explanation of the national policies. therefore, the critical reflection on equity is three-fold: 1) to what extent the national policies approved by central government concern with the equity between regions. 2) how the policy in local Government delivers the equity between schools in the same region. 3) how the policy reform influence at school and teacher level to deliver educational equity for every student.

Second, adequacy is also a two-dimension value. The first dimension is that Government needs to provide enough resources for schools to deliver quality education. The resources contain educational facilities and sufficient teachers. The second dimension is that schools need to provide adequate and quality education to attract students to access. In general, reflection on the adequacy value should not only concern with the sufficiency of resources providing to school, but also address on the valid outcomes of schooling to meet student's needs which can be urgent or long-term.

Third, efficiency is a common concern from the Government and policy makers, which can be a two double-edged sword. Fullan (2007) demonstrated that Governments are expecting a world of quickly solving for urgent problems. Therefore, the efficiency value raises the question of whether the investments in education are efficiently used in schools to make significant improvement for students. The reflection on the efficiency value is mainly focusing on the role of the Government and its effects on implementation.

Last, the choice value has three dimensions. The first dimension is the choice of school for students and their parents. While choosing schools, students and parents used to pay attention on students' performance in previous years and the education quality of the school. The second dimension is the choice of subjects for the examination for students. As reviewed in the literature review chapter, students' power and perspectives are increasingly emphasised in high school schooling. The third dimension is the choice for schools at local level. It is about how are schools to adapt to the reform and make their local-based or school-based decisions on further development.

Equity

Equity between regions

As reported in documents, the results demonstrate that goals of educational equity between regions in the last five-year plan (till 2015) have been basically achieved. Efforts of policies are mainly in two aspects: one is to increase the gross enrolment rate of upper secondary school; the other is financial support to regions with difficulties. These two aspects are also emphasised in this reform, as several mid-term and long-term policies have mentioned that the equity between regions would be significant tasks for Government.

Although the enrolment rate of high school has increased to 87 percent, based on the statistics of educated people from the national census in 2018, there were only 13.1 percent population with high school diploma nationwide. Also, compared with the nation level, provinces in the western part of China have lower proportion of under 10 percent. This circumstance led the Government continuing to consider the equity between regions and set up goals that:

By 2020, nationwide high school education will be popularized to meet the needs of junior high school graduates to receive good high school education. The gross enrolment rate of the whole country and provinces (autonomous regions and municipalities) has reached more than 90%, and the gross enrolment rate of poverty-stricken areas in the central and western regions has increased significantly; the structure of ordinary high schools and secondary vocational education is more reasonable, and the enrolment scale is roughly the same. (High School Education Popularisation Program)

Therefore, policies for the educational equity between regions claim the action that the resources need to allocate to poverty areas with a series of projects to raise the educational quality and enrolment rate. However, these areas need not only the financial support to build new schools, but also quality teachers to provide the same level education.

Equity between schools

The term ‘property near key schools’ or ‘school district’ is becoming a hot topic in family with middle school students in China. This indicates that the imbalance of schools in one city or district, which also cause the inequity in educational resource allocation. The inequity between schools has two connotations: one is the imbalance between key schools and others; the other is the imbalance between general high schools and technical secondary schools. From the policy documents reviewed in this study, the latter one is mentioned more in the mid-term national plan policies, while the former one is mainly mentioned in teacher management policies.

technical secondary schools*: increase the enrolment ratio of secondary vocational education through measures such as expanding secondary vocational education resources, implementing the vocational education industry-education integration project, running special and advantageous majors, and establishing a unified recruitment platform. (High School Education Popularisation Program)*

Teacher management: *Adhere to the priority guarantee of investment in education and continuously improve the treatment of teachers. Effectively implement the school's autonomy in distribution and lean towards teachers with outstanding teaching achievements and outstanding teaching achievements. Implement policies such as rural teachers ’work subsidies for townships, living allowances for concentrated contiguous poor areas, and subsidies for hard and remote areas, and grant transportation to teachers with teaching tasks in rural areas where conditions permit. Strengthen the construction of teacher dormitory in rural schools. (Opinions on Strengthening and Improving the Teaching and Research of Basic Education in the New era)*

This may indicate that the central Government still put much effort on developing high school level education system to ensure post 16-year-old teenagers got educated in schools. Measures reducing the inequity between schools are mainly focus on raising teachers’ treatment to encourage skilled teachers to transfer to teach in lower-level schools. However, these policies may not be able to solve the problem because teachers may not be willing to change their living status for a better treatment. Therefore, the inequity between schools would be still existing and need more effort to solve this issue.

Equity between students

Equity between children is the most concerned value in analysed policies, which nearly mentioned in every documents. The core purpose of these policies is to help students and family with difficulties to receive same level education. these children and their family are defined in three categories with different measures. The first, which is called as *targeted poverty alleviation* policy, is to ensure every child receive education and making specific subsides plan for each family according to their needs. The second is to promote the development of special education for students with disabilities. The third measure is aiming at the group of children whose parents are working in cities from rural area. They usually do not have neither stable job nor high salary. Their children's rights to receive equal education need to be protected and guaranteed.

In the first policy, *targeted poverty alleviation,* a large and ambitious policy aiming at the poverty people who still have large population in China. Since 2010, the standard of sponsoring students with economic difficulties to attend high school education increased from 1500 Yuan per student per year to 2000 Yuan per student per year in 2015. In addition, this policy aims to establish a database for poverty family in rural areas to improve the accuracy of helping every child receive quality education. The policy is for equity instead of equality because it gives opportunities to students with difficulties.

Adequacy

Adequacy resources from Government

The consideration of adequacy firstly focuses on the resources required by the Central Government and local Government, which provide the stable financial support to education to ensure adequate educational resources. As reviewed in the curriculum development history in Chapter 2, the term of 'Quality Education' started to be used in basic education policies, which indicates that the central Government set up educational adequacy as a main goal from 2000. As shown in '*High School Education Popularisation Program (2017-2020)',* many shortages have been reported to critically evaluate the work

of adequacy at the high school level.

Many schools have weak schooling conditions and are difficult to meet basic teaching needs; a reasonable funding mechanism is not yet perfect, and the debt problem of general high schools has not been effectively resolved; the total number of teachers in general highs schools is insufficient.

Thus, dilemmas of adequacy at high school level in this reform are two-fold: one is the debt problem of high schools; the other is the lack of teachers. For the former dilemma, main means are to improve the funding mechanism and set up timeline for repaying the debt since 2014. However, the imbalance between regions may hinder the implementation. Thus, as mentioned in '*Guiding Opinions on Promoting the Educational Reform of General High Schools in the New Era',* regions with difficulties can postpone the improvement until 2022 while other regions need to accomplish by 2020.

From the policy documents reviewed, the mean to the first goal of adequacy is not a strong and urgent one with two probable reasons: one is debt of high schools is a long-term issue started from 1990s when the scale of high schools was growing fast. The main purpose in this reform is not to eliminate the debt, but to control its growth through adjusting the tuition fees and standardising school expenditures. The other reason is that this financial problem is a contractual issue. A large proportion of these debts were loans for school infrastructure construction which can be gradually involved in the replaying plan of local Government.

The inadequacy of teachers is a main issue mentioned in several reviewed policy documents. There are two means to this goal of providing sufficient and quality teachers for high school level education. one is to improve pre-service teacher education in higher education. the other is to enhance the training for in-service teachers.

Pre-service teachers*: Guide and support the undergraduate majors in normal schools and increase the training of undergraduate teachers at the compulsory education stage. In accordance with the relevant procedures and measures, a number of authorization points for master's degree in education will be added. Guide and encourage relevant universities to expand the enrolment of graduate students in education and provide overall support to the indicators for the promotion and*

exemption of postgraduates in teacher education colleges. Support normal colleges to expand the enrolment of special education majors and increase the training of graduate students in special education.

***In-service teachers**: Teacher training funds should be included in the financial budget. The school arranges teacher training funds at 5% of the total annual public expenditure budget.*

This mean indicates the financial support to ensure the number of new teachers and quality of skilled teachers. In addition to the financial support of Government, teachers' moral education is emphasised in several documents.

***College students**: Teacher moral education runs through the whole process of teacher education as a required module for teacher training and teacher training courses.*

***In-service teachers**: Chinese traditional culture education is widely carried out, focusing on the cultivation of teacher ethics through Chinese excellent traditional culture, through the classic recitation, the establishment of special courses, the organization of special training, etc., to absorb the cultural essence and inherit the Chinese teaching.*

The strengthen on the moral education for pre- and in-service teachers would be shown in implementation of teacher training and would be demonstrated in teacher evaluation. The following excerpts can clearly show the new requirements in teacher evaluation.

Focus on strengthening the supervision and supervision of teachers' ideological and political qualities, teachers' ethics and ethics, strengthen teacher's ethics evaluation, reflect rewards and punishments, implement a negative list system of teacher's ethics assessment, establish teachers' personal credit records, improve integrity commitment and punishment mechanisms for dishonesty. Focus on solving problems such as anomie of teachers' morality and academic misconduct.

Therefore, the circumstance of this reform is the stress on moral education which would be the new baseline of teacher education. This may due to the standard of high-quality teachers with great teaching skills and high moral standing. However, there may

have contradiction between the urgent demand of basic education teachers and the raised standard of teachers. In less developed regions, the implementation of this moral training and evaluation may be discounted or neglected.

Adequate and quality education offered by schools

In this curriculum reform, the inadequacy at high school level mainly focuses on the enrichment of subjects, activities, and teaching approaches. There are two types of schools at high school level: general high school and secondary (technical) vocational school. The following excerpts describe the goals for these two schools in '*High School Education Popularisation Program (2017-2020)'*

General high school: *Strengthen the general high school curriculum selectivity, promote course selection and classes to meet the diverse needs of students.*

Vocational school*: Improve the attractiveness of secondary vocational education majors, strengthen technical skills training and cultural basic education to achieve the ability to obtain employment and have a foundation for further education.*

As all general high schools all over China need to implement the new curriculum and new textbooks by 2022. Principals are the firstly trained and responsible to the translation of the policy to teachers. They are also the main power to promote the curriculum reform implementation. The adequacy for schools to offer quality and selective curriculum claims that general high schools need to develop their school-based or local-based curriculum by utilising resources inside and outside schools. However, the understanding of principals on the new curriculum and schools' resources can be the challenges of the implementation of this policy, which may depend on the effects of principal training and actual practice.

On the other side, means for vocational schools focus on raising teaching quality to attract applications. Vocational schools in China still existed for the supplement for general high schools. There are two ways for these vocational schools to develop: one is to base on high quality technical education to enhance graduates' professional skills; the other is to combine with the general high schools to let general high school students

have more choices.

Implement the integration of production and education in vocational education, promote the integration of professional settings, curriculum content, teaching methods and production practices in secondary vocational schools, concentrate on building a number of high-level vocational schools, and run a number of specialty specialties that meet local economic and social needs. Establish a guidance system for student development, and strengthen guidance for students in course selection, further education and employment.

Explore and develop comprehensive high schools, improve support policies for curriculum implementation, student status management, and examination enrolment to provide students with more choices. Establish a cooperation mechanism between ordinary high schools and secondary vocational schools, and explore the mutual selection of courses, mutual recognition of credits, and mutual exchange of resources.

However, the focus of this reform would still be the general high schools. Government's support to the local vocational education is limited and unclear. They need to look for social funds and cooperate with local industries. The teaching quality of these schools are hardly guaranteed. The only thing can be done by the policy makers is to give them room for free development.

Efficiency

In Chapter 2, I have discussed that 'reform' has becoming a popular term in educational development in China since 1978 when the 'Reforming and Opening up' policy was implemented. Governing in China was used to achieve policy goals as an authoritative tool which is usually dedicated to benefiting a wider group or society as a whole. Thus, as Fullan (2007) pointed out, Government in China face a dilemma with educational reform, especially in large-scale or nationwide. Efficiency asks the Government to achieve the goals as quick as possible with the lowest cost and asks schools to utilise the resources efficiently to make the changes. However, in a complex large-scale reform, policies from the central Government need agents and official at local levels to carry out. There may has a potential danger in misunderstanding or

misinterpreting in implementation process. In China, the term 'danger of bureaucracy' is often used to describe this phenomenon in the national reform at local level. Therefore, the role of Government is essential in educational reform and have critical effects on the implementation.

From reviewed documents in this reform, it is one positive change in policy making process that stakeholders are encouraged to participate into the policy making and discussion. Take the making process of '*Teacher Education Promotion Action Plan (2018-2022)'* as an example in the Table below.

Table 4.3

Timeline of making process of 'Teacher Education Promotion Action Plan (2018-2022)'

Time	Procedure	Action
04/2016	Systematic research	Comprehensive survey to understand the current basic situation of teacher education colleges and students in the country and the relevant situation of teacher education financial investment
05/2016	Document development and drafting	Set up a special drafting group to prepare the discussion the draft and communicate and consult with relevant ministries and commissions on the policy issues involved to form a consultation Draft.
Since 08/2016	Solicit opinions	Operate Consultation seminars, Teacher seminars, National Conference on Teacher Education Promotion and Teacher Team Construction to collect opinion on the draft from local education administrations, normal colleges, and representations of teachers.
2017	Amend to the final version	According to opinions, the draft was amended and then finalised as the document.

It is a good signal to have local opinions involved into the policy making process. However, there are still some concerns in this change. Firstly, due to the time and scale of consultation, it may not be able to collect enough information and opinions to amend the policy. Secondly, the group of teachers are represented by some 'elite' teachers who may not be able to stand for teachers at all levels. Thirdly, the impact of opinions from schools and teachers on policy making is still unclear to public. Last, local opinions may be more considerable in short-term policy than long-term policy. Thus, more efforts are still needed on listening to the reflection of social groups to the policy.

Everyone should also cultivate a sense of active participation in discussing policies related to their interests.

Although there are many uncertain effects on the role of Government, this change may indicate that the Government start to seek a path to adjust their role on reform to make sure the policy adapts to local circumstance and promote the valid implementation in teaching practice.

Choice

Choice of schools

As mentioned before, there are two types of schools at high school level: general high school and (technical) vocational school. As reported in the document '*Thirteenth Five-Year Plan' for National Education Development* and *High School Education Popularisation Program (2017-2020),* the proportion of high school level students aims to increase from 87% to 90% of the population (shown in Table 4.4).

Table 4.4

Number of High School level students

Type of school	Number in 2015	Goal number in 2020
General high school	23.81 million	22.6 million
Vocational school	16.57 million	18.7 million
Total	40.38 million	41.3 million
Proportion of enrolment	87%	90%

The decrease of general high school students in this policy goal indicates that parents and students are encouraged to attend the vocational schools to balance the two types of schools. Therefore, the goals and means to goals for general high schools and vocational schools are different in subject development, teaching approaches, and students' future career.

Choice of Subjects in General high school

As reported in *Guiding Opinions on Promoting the Educational Reform of General High*

Schools in the New Era, there are six specific goals for general high schools:

1. *General high school new curriculum standards and new textbooks are fully implemented.*
2. *Promoting in-depth teaching reform adapted to students' comprehensive and individual development.*
3. *The teaching management mechanism of course and subject selection*
4. *Scientific education evaluation and examination enrolment system are basically established.*
5. *Teachers and school conditions are effectively guaranteed*
6. *The pattern of diversified and characteristic development of general high schools is basically formed.*

The new curriculum standards and plan were discussed and revised by the *Basic Education Curriculum Textbook Expert Working Committee* which have about 260 curriculum experts. The first edition of new curriculum standards and plan were published in January 2018 and revised in June 2020. According to the interview of officials from the *National Textbook Committee Office,* he introduced the review group who oversaw the revision work.

The curriculum plan review team *consists of more than 40 experts and scholars from academic disciplines including education, psychology, Chinese, mathematics and other disciplines, who are familiar with education and teaching practice, including academicians and senior professors.*

The curriculum standard review group *is composed of 179 experts, one review group for each discipline, and a comprehensive review group is established specifically.*

The comparison of the general plan and curriculum standards between the old (2003 version) and new (2020 version) curriculum would be reported in the next section.

New textbooks were also edited by National Textbook Committee. Detailed distinguish with the old textbooks would be reported in next section.

The teaching reform in general high school firstly focuses on the course and subject selection. The means in this reform are to develop the curriculum management

and to implement the policy of ‘subject and course selection’

According to the ordinary high school curriculum plan, the three-year courses of various disciplines are reasonably arranged, and the courses of sports and health, arts, comprehensive practical activities and physical and chemical biology experiments, etc. are fully opened. Strengthen the construction of school-specific courses, and actively carry out community sports such as campus sports, art, reading, writing, speaking, and technological innovation.

Adapt to the new curriculum reform and comprehensive college entrance examination reform of general high schools, according to the discipline training law, the requirements of college entrance examination majors and students' special interests and implement localised courses to meet the different development needs of students.

This policy of ‘subjects and course selection’ may be the largest challenge for schools in implementation process. Firstly, the inadequacy of teaching resources and experienced teachers would delay the timeline of implementation in some regions. This may cause the difficulties in school management and teacher training. Secondly, teachers oversee the teaching process in traditional classroom in China because of the amount of a class with no less than 30-40 students, thus, teachers cannot take care of every student’s needs. The role of teachers may have changes on classroom teaching, which may be difficult for in-service, especially higher seniority, teachers. Last, the role of students may also change in the new curriculum. They need to have more responsibility with their interests and future development. In addition, there may have difficulties for parents to understand the new policy.

4.2.3 ***Discussion***

To answer research question 1a and gain a deeper understanding of why the new curriculum reform policy is being presented in its unique way currently and place. While following its specific developmental path, it is necessary to analyse the specific context on which the new curriculum reform policy relies. This analysis was helpful to understand how various external social conditions participate in the process of constructing curriculum reform policies and have substantial impacts on these policies.

This section discussed from the economic, political, and social circumstances of the new curriculum policies to search and locate its value orientation and ecosystem.

Economic Circumstance

In the early stages of curriculum reform, as China's economy entered a new normal during the 'Thirteenth Five-Year Plan' period (2016-2020), it became a critical time for economic transformation and upgrading. During this phase, the role of education has become even more important and urgent. Education needs to cultivate and supply various types of talents and high-quality workers to society, while also playing a greater role in innovation and development.

To meet these requirements, the national level has put forward a series of goals and plans in talent cultivation. Firstly, students' moral character, scientific literacy, and physical and mental health should be significantly improved. They should possess strong sense of social responsibility, legal awareness, innovative spirit, and practical abilities. Secondly, adjustments and optimizations are needed in the structure of talent cultivation. As mentioned, both in *'Thirteenth Five-Year Plan' for National Education Development* and *China Education Modernisation 2035.* This would adapt to the needs of national and regional economic and social development and enhance competitiveness in international competition.

There is a need to increase the proportion of innovative talents, versatile talents with multiple skills sets, application-oriented talents, and technically skilled personnel; thus, making the talent cultivation structure more reasonable.

Finally, the education system also needs to focus on the service roles that different types of talents play in national and regional economic and social development. By providing relevant professional knowledge and skills training，education can help different types of talents better adapt to and serve the needs of national and regional economic and social development.

Therefore, to adapt and coordinate the new competition and distribution of interests in society, there need more flexible and fair social coordination mechanisms, market principles, and work procedures. The way society operates should meet the

diverse needs of different individuals and provide conditions and possibilities for both competition and cooperation. Reflected in curriculum policies, the first change is the shift in student perspectives, emphasizing students' autonomous learning and exploration. It recognizes the wide range of differences among students as well as their uniqueness, acknowledging their potential for multidimensional development along with its process-oriented nature. This directly leads to curriculum objectives that focus on developing students' core competencies.

Furthermore, based on the full exploration of the core qualities required for economic and social development in the new era, such as critical thinking, practical abilities, environmental awareness, and moral wisdom, a new educational perspective has emerged. To enable learners to actively engage in their own lives and contribute to society's public welfare autonomously, this awakened consciousness within the new educational concept has consequently brought about comprehensive changes in curriculum policies regarding content, structure, teaching methods, and evaluation.

Secondly, in modern society, simply adapting to job requirements with basic knowledge, fundamental learning abilities, and practical skills is no longer sufficient to meet the demands of the new economic landscape. To tackle globalization challenges, the ability to gather and process information, assess its value, analyse and solve real-world problems, as well as communicate and collaborate effectively have become new indicators for measuring work capabilities. This necessitates that learners possess intrinsic motivation and engaging learning experiences while also having self-awareness and reflective abilities. They must be willing to think critically, explore new ideas, challenge existing norms, innovate, and put theory into practice. This also indicates the need for Chinese learners to break away from traditional collective thinking patterns of the past and fully embrace individual needs and a sense of agency.

Finally, the emergence and development of economic consciousness in curriculum policies promoted the professionalization of the basic model and process of curriculum policy operation, which require theoretical justification and scientific norms for curriculum specialization. This also includes the professionalization of personnel involved in curriculum, on one hand organizing professional teams for curriculum

development and design, conducting experiments and professional training for curriculum reform; on the other hand, reforming teacher education to cultivate a specialized and high-quality teaching workforce that adapts to new curricula. Emphasizing the degree of professionalism in curriculum policies fundamentally ensures the quality and effectiveness of curriculum reform, which is also a direct result brought about by the new economic environment.

Political Circumstance

The direction of institutionalizing political democracy and legalization from 'party ruling the country' to 'rule by law' not only rationalizes the relationship between the Party and the government, but also clarifies the power of the government and the roles of administrative organs. It also deepens the reform of the administrative system, dispersing highly concentrated state power, and establishing a service-oriented, responsible and law-based government. Local government and social organizations need to embody their autonomy, and further contributed to the institutionalization and standardization of policy decision-making, administrative management, and the overall effectiveness of organizational structures and mechanisms. Reflected in the field of education, the first is to emphasize the reform of educational administrative management system, which is classified management, division of labour is responsible for, through simplify policies and delegating powers, to change the current situation that education administration in China is too centralized and unified, and the administrative ability of local government is not strong.

In the new curriculum reform, it is advocated that under the overall leadership and management of the central Ministry of Education, local educational administrative authorities should be responsible for curriculum reform, determining specific reform policies, systems, and plans at the local level, as well as providing guidance, management, and inspection for school curriculum reform. A significant impact is reflected in the formulation and operation of new curriculum reform policies which have begun to demonstrate a tendency towards democratization and institutionalization in terms of organizational processes and structures. For example, establishing professional committees for curriculum reform, deploying work functions of education

administrative authorities at all levels; conducting public opinion surveys, announcements and hearings on policies; policy experimentation and feedback; as well as legitimizing curriculum reform policies through power and administrative agencies. All these measures ensure standardization and legitimacy in policy development from an organizational structure and operational perspective while serving as the foundation for democratic politics.

Besides, in the policy environment of curriculum reform, there is an underlying and continuous struggle between old and new political ideologies and political cultures. Under the conditions of political system reform, the emergence of a new political culture continuously challenges past political ideologies. The advocated concepts in the field of curriculum policy, such as equal participation rights in curriculum decision-making and emphasis on curriculum serving individual freedom development, are a critique against the tendency towards political authoritarianism resulting from traditional political cultures that disregard subject consciousness and unilaterally emphasize public obedience to authority. It attempts to promote a participatory political culture by strengthening opinion expression and negotiation among curriculum stakeholders.

Relying on the existing achievements of political system reform and the development of democratic politics, in the field of curriculum, there have been indications of a democratic and law-oriented political development through expanding participation in curriculum decision-making, promoting decentralization in curriculum authority, and institutionalizing and legitimizing the process of curriculum formulation and implementation. However, the reality is that compared to economic system reform, it is still evident that political system reform lags, with an immature and imperfect socialist system.

Social circumstance

The transformation of social structure has directly led to the political awakening of the public, manifested in a surge of enthusiasm for democratic participation in policy processes and the gradual cultivation of civic consciousness. The public demand understanding, participation, and expression of their own will and voice. In the field of

education curriculum, this is reflected in a repositioning and value transformation of education within the social system. In China, education is either attributed to the superstructure of national politics or classified as part of the economic foundation in the industrial development. This may result in a broad politicization and economization of educational values.

Therefore, when the educational value reflects a clear utilitarian tendency, it may lose its intrinsic independence and fundamental pursuit of values. However, as certain regions experience economic development and trigger new social structural changes, education and curriculum establish themselves as a new entity between the government and the market, gradually breaking free from their purely instrumental value serving politics or economics. Upon entering the public domain, they establish their commitment to social justice and public service values. During the stage of curriculum policy reform, it is necessary to establish a more flexible concept and operational model that encourages public participation and introduces democratic consultation and oversight mechanisms. In addition to this, during the implementation phase of the new curriculum, it is crucial to fully stimulate participants' enthusiasm. The choices made by local communities and schools' curriculum leadership and management directly influence the progress of curriculum reform implementation while receiving clear feedback within the management system of the new curriculum.

In the current social reality of China, the unfair allocation of public resources caused by an unreasonable social class structure is triggering deeper social inequality in terms of opportunities and reproduction of social classes. This is reflected in the education sector through unjust educational streaming, unequal educational opportunities, and unfair allocation of educational resources. The emergence of these problems is partly due to adverse structural contradictions within society, but also due to inherent flaws within the education system such as knowledge-centeredness, selectionism, cutthroat competition, and dominance of exam-oriented elitist education. These flaws reinforce feudal traditions that strictly rank individuals, artificially divide them into layers, suppress their personalities and values. It is against this backdrop that promoting harmonious social development and achieving fairness and justice in

education have become the main values pursued by our current education system. The new curriculum reform policy clearly advocates a transition from ‘elitism’ to ‘mass orientation’, aiming to replace old selective education that tames students into becoming ‘elites’ with a focus on guaranteeing every student's right to learn and pursuing each student's development.

4.3 Comparative analysis with the new science curriculum standards and textbooks

The new Physics curriculum standard was published in 2017 by MOE, while the new Physics textbooks were published by People Education Press in 2019. In terms of objectives, content, and assessment, there have been significant changes. The curriculum objectives have shifted from three-dimensional teaching goals to core competency development goals; the curriculum structure has changed from compulsory courses plus three series of elective courses to compulsory courses plus selective compulsory and elective courses; the content requirements have transitioned from emphasizing knowledge requirements to encompassing physical concepts, scientific thinking, experiences, and exploration; learning requirements and evaluation have evolved from a single 'content requirement' to a comprehensive assessment system composed of 'content requirement,' 'academic requirement,' and 'academic quality level.' This section analysed and compared the various parts of the curriculum standards in text before exploring the changes between the old and new textbooks by integrating them with the changes of curriculum content in curriculum standards.’

4.3.1 *Basic Principles of the Curriculum*

As shown in the table, a comparison of the texts regarding the fundamental principles of the curriculum reveals two main changes in their expressions. Firstly, the new curriculum standards emphasize cultivating students' physical literacy, whereas the old ones focused on their scientific literacy. Secondly, there is a clearer and more targeted expression. For instance, in terms of evaluation philosophy, addressing the current situation where teaching places more emphasis on outcomes than processes and

prioritizes knowledge over competencies, it explicitly proposes to '*emphasize process evaluation and promote the development of students' core competencies*'.

Table 4.5

The basic idea of new and old high school physics curriculum standard

	Old Physics Curriculum	New Physics Curriculum
Objectives	Improve the scientific literacy of all students.	Reflect the essence of Physics and cultivate students' core competencies.
Structure	Pay attention to the foundation, reflect the choice of the course.	Pay attention to the basic and selective curriculum to meet the needs of students' lifelong development.
Content	reflect contemporaneity, fundamentality, and selectivity	Emphasizing the timeliness of courses, focusing on technological advancements and societal development needs
Implementation	Emphasizing self-directed learning and advocating for diverse teaching methods	Guide students to learn independently and advocate for diversified teaching methods
Assessment	Emphasizing the update of concepts and promoting student development	Emphasizing process evaluation to promote the development of students' core competencies

The first specific statement of the new curriculum standard states:

High school physics courses emphasize the essence of the discipline, extracting the educational value of physics from aspects such as physical concepts, scientific thinking, scientific inquiry, and scientific attitudes and responsibilities. It fully embodies the unique role of physics in enhancing students' core literacy and lays a foundation for their lifelong development and ability to cope with challenges in modern and future society.

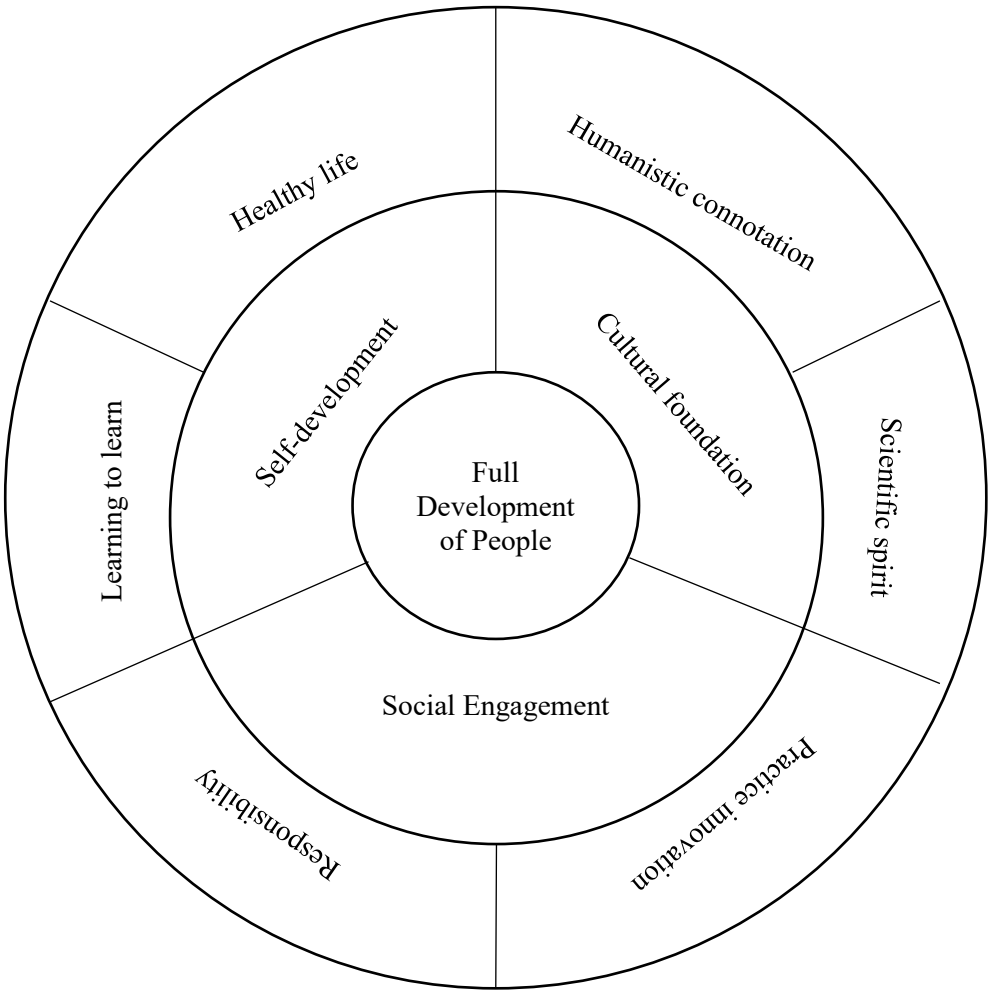
Compared with the old curriculum standard, it can be seen that the main change in the curriculum concept of the new standard is transforming the previous three aspects of ‘knowledge and skills,’ ‘processes and methods,’ and ‘emotional attitudes and values’ into four core competencies requirements: ‘physical concepts,’ ‘scientific thinking,’ ‘scientific inquiry,’ and ‘scientific attitudes and responsibilities.’ This transformation makes high school physics teaching philosophy shift from relatively abstract 'three-dimensional goals' to concrete, actionable 'core competencies'.

4.3.2 *Aims and Objectives*

The old curriculum objectives of all subjects were arranged into the three-dimensional goal system: *scientific knowledge and skills, process and methods, and attitudes and values*. The core competences system (shown in Figure 4.2) helps this reform change the three-dimensional objective system.

Figure 4.2

Core competencies for developing 21st century young generation (Core Competencies Research Group, 2016)

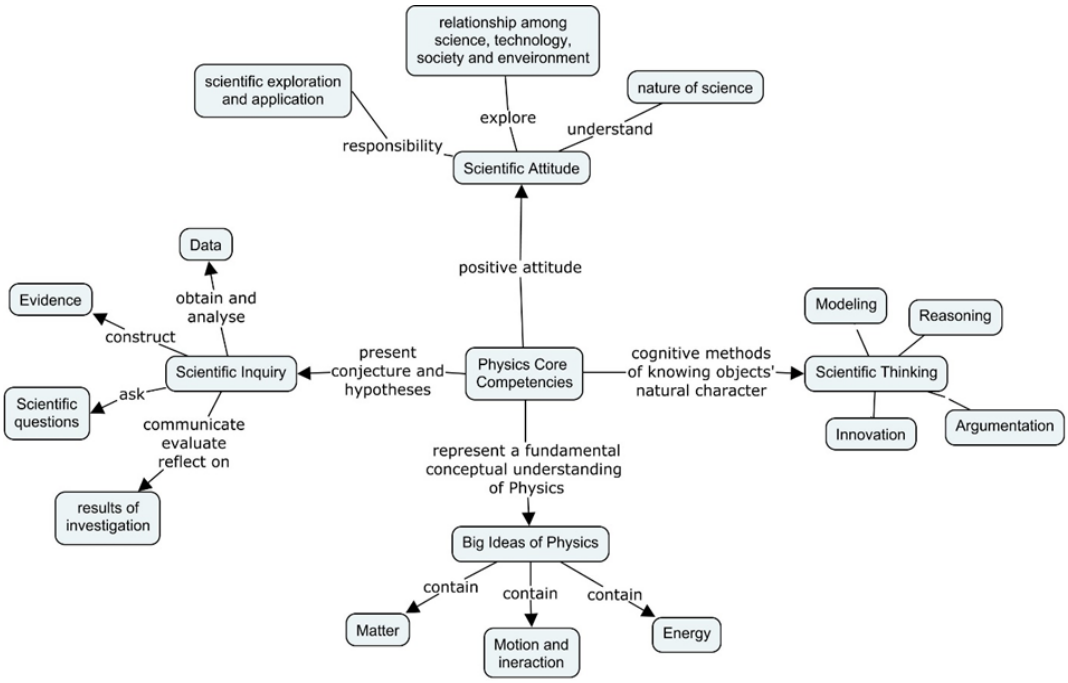


While translating these core competencies into subject level, they are developed to the subject core competencies as goals of school science. Physics core competencies consist of four dimensions which represent the high school Physics standards. To make

it visible, I produce a concept map (Figure 4.3) with detailed explanation.

Figure 4.3

Physics core competencies



The new Physics standard defines core competencies of Physics subject as 'correct values, essential characters and key abilities that students gradually form through subject learning', which contain *Physics concept, Scientific thinking, Scientific inquiry, and Scientific attitudes and responsibility*. The first two themes are newly added to the curriculum standard.

Big Idea of Physics

Big Idea of Physics is defined as 'The refinement and sublimation of Physical concepts and laws in the mind' in the new standard. The old curriculum emphasised Physics concepts and laws while the new curriculum standard stressed on the understanding of these concepts and laws and their applications. These concepts and laws are categorised into 'Matter', 'Motion and Interaction', and 'Energy', which is similar as *core concept* or *big idea*. This may raise new requirements for teachers to summary and improve the basis of concepts and laws and construct these big ideas for students.

Scientific thinking

Cultivating students' scientific thinking as the core objective of learning Physics in the new curriculum contains 'Model Construction', 'Scientific Reasoning', 'Scientific Argumentation', and 'Questioning and Innovation'. The new standard stressed on scientific thinking competencies to prominent the function of Physics learning, which can help students establish scientific models with science methods. This requires students to be able to analyse, reason, summarize and demonstrate the physical processes while constructing physical models. It also emphasizes the importance of maintaining a questioning and critical spirit towards different perspectives and conclusions, fostering creative thinking and learning approaches.

Scientific Inquiry and Scientific attitudes and responsibility share similar core content with previous course objectives. Scientific inquiry emphasizes the ability to identify problems, propose reasonable hypotheses, and conduct observations and experiments. Scientific attitudes refer to understanding the essence of science and recognizing the relationships between science, technology, society, and the environment.

In summary, the objectives of the old curriculum are developed from three aspects: 'knowledge and skills,' 'processes and methods,' and 'emotional attitudes and values.' The objectives of the new curriculum, on the other hand, are described from the perspective of physics core competencies. Physics core competencies is a further clarification and refinement of the three-dimensional objectives based on disciplinary characteristics, with a clearer and more specific connotation. For example, in the aspect of 'processes and methods' within the three-dimensional objectives, it does not specify which specific methods should be learned at the high school physics stage. However, in terms of scientific thinking requirements within physics core competencies, it introduces methods such as 'model construction,' 'scientific reasoning,' 'abstract thinking,' 'variable control,' and 'limitation thinking.' Nevertheless, both 'three-dimensional objectives' and 'core competencies' share people's expectations for education to cultivate individuals with comprehensive development. They bear responsibility for addressing past exam-oriented education that emphasized students'

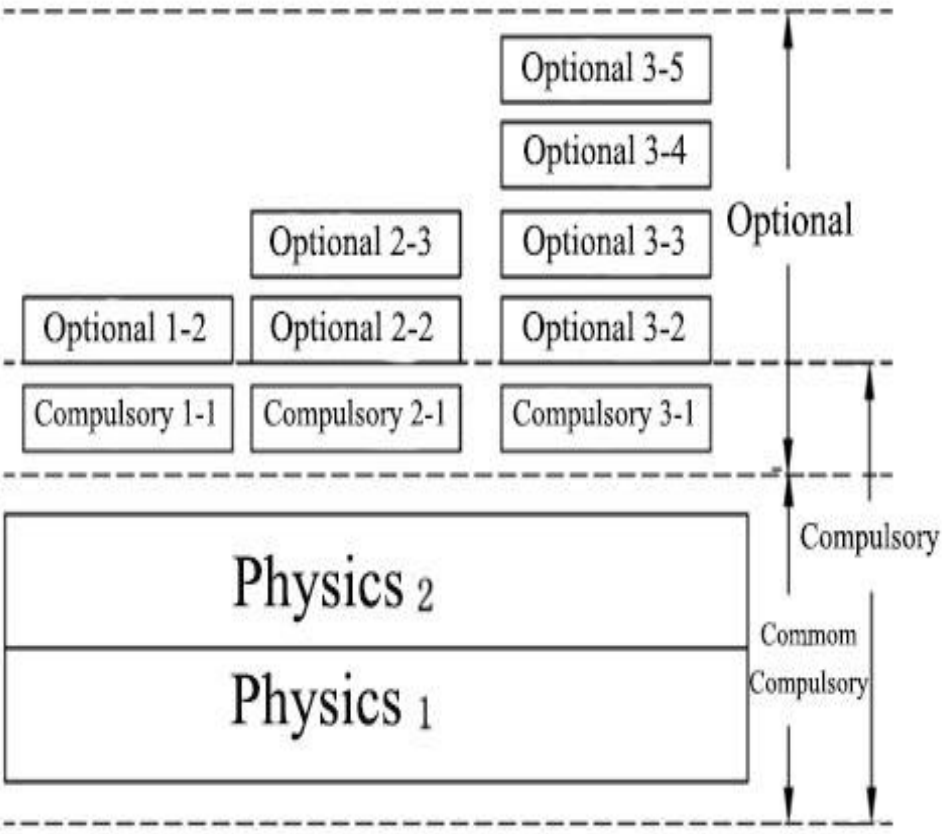
test scores and schools' pursuit of admission rates. As a result, they exhibit an inherent relationship of inheritance between them.

4.3.3 *Curriculum structure*

'The curriculum structure of the new physics curriculum standards design has undergone significant changes compared to the old version: while emphasizing common foundations, it further enhances the selectivity and diversity of the curriculums. For specific comparisons, please refer to Figure 4.4 and Figure 4.5.'

Figure 4.4

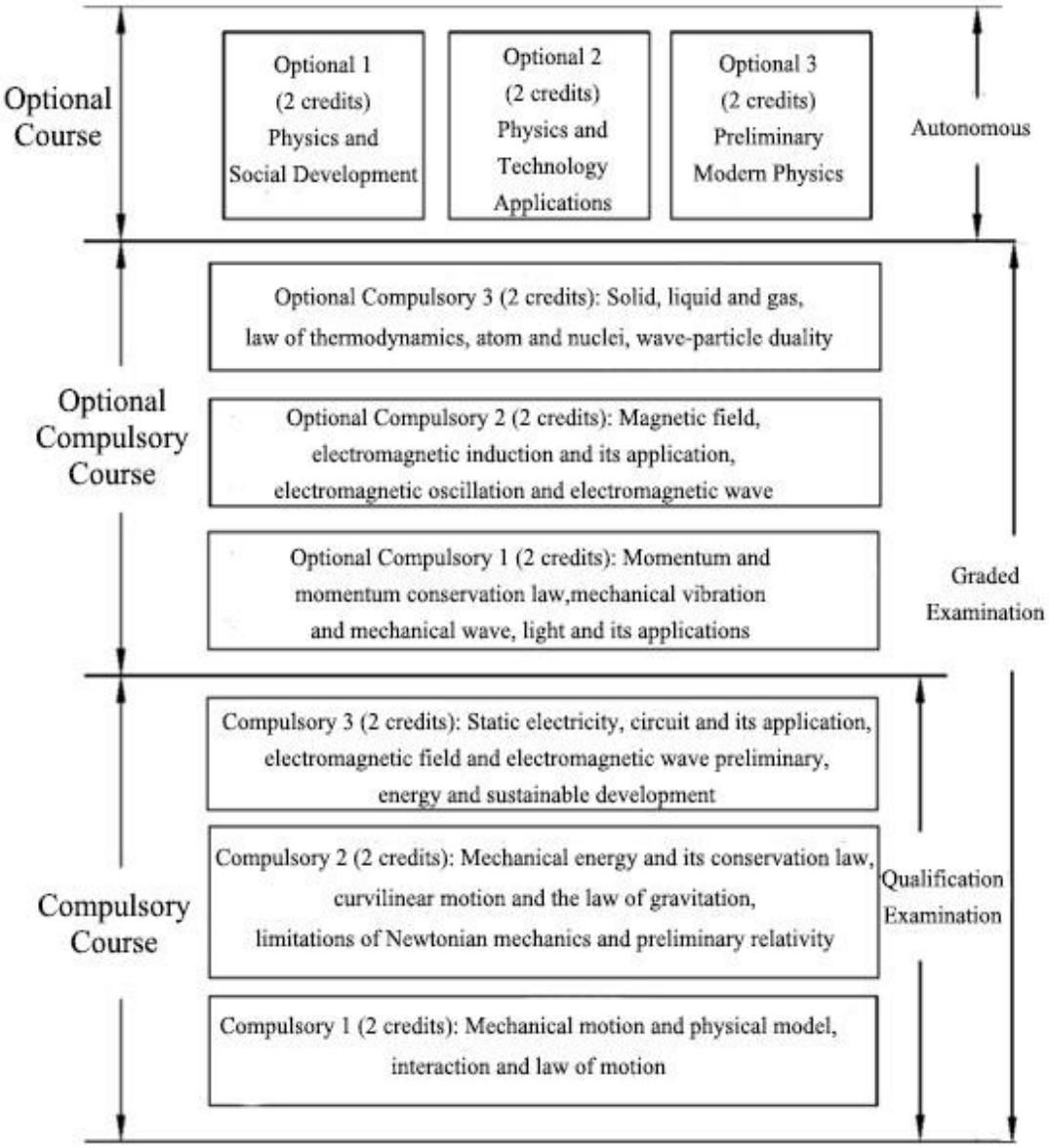
Old Physics Curriculum structure in 2003



In high school, the compulsory credit for physics courses is 6 credits. Under the

Figure 4.5

New curriculum structure 2017



old curriculum standards, there is a common compulsory module worth 4 credits. Additionally, students are required to choose one module worth 2 credits from either the optional series leaning towards humanities and social sciences (Optional Series 1), the optional series focusing on technological applications (Optional Series 2), or the optional series aimed at further in-depth study of physics (Optional Series 3). Generally, liberal arts students would choose optional Series 1-1 and after completing it and participating in academic examinations, they would no longer continue studying physics. On the other hand, science students would opt for Optional Series 3. As for

Optional course series 2, due to not directly corresponding to the Gaokao, it is rarely chosen by schools.

The curriculum structure designed in the new version of the curriculum standards is aligned with the Gaokao and college admissions. After completing the 6-credit common compulsory module, students who choose to take physics in their college entrance exams need to further study a 6-credit elective compulsory course. For students who do not choose to take physics, they can either choose not to study the subject or select from modules such as ‘Physics and Social Development’ or ‘Physics and Technological Applications’ within the elective series, or other school-based optional courses related to physics based on their own interests. Their autonomy in choosing both space and content increases significantly.

For students who choose to take physics in their college entrance exams, besides studying elective compulsory courses, they can also freely select all modules within the elective series. This broadens their horizons and deepens their understanding of physics, especially giving more room for those who excel in this subject through modules like ‘Introduction to Modern Physics’.

Meanwhile, the new curriculum standards in the national curriculum grant school’s greater autonomy and place a stronger emphasis on encouraging the implementation of localized national curriculum, particularly in elective series. The curriculum standards explicitly state that 'schools may offer elective courses and conduct independent assessments based on actual circumstances.' This adjustment in the curriculum structure aims to ensure foundational knowledge while also providing students with more personalized choices and expanding prospects for the development of elective courses within schools.

4.3.4 *Content analysis of the Physics curriculum standard*

The comprehensive descriptions of the changes (adds and deletes) with reasons are shown in Table. The main structure of knowledge has not been changed. As analysed in the above sections, elective courses leave more room for schools at the institutional level. Therefore, here I only compared the content of compulsory and selectively

compulsory courses with the corresponding content in the original curriculum standards. To highlight the differences between the two versions, specific additions, deletions, and adjustments of each subtopic are presented in tabular form below.

Table 4.6

The changes of compulsory content in physics curriculum between version 2003 and 2017

Themes	Addition	Deletion	Adjustment	
			Old	New
Mechanical motion and physics models	Experience the abstract approach in scientific thinking and the boundary method in the investigation of physics phenomena. Through experiments, the law governing the motion of freely falling bodies has been comprehended. By integrating it with pertinent aspects from the history of physics, a profound understanding is gained regarding the pivotal role played by physics experimentation and scientific reasoning in advancing research within this field.	~~Experience the significance of mathematics in the study of physics problems.~~	By comprehending the particle's nature, enabling a profound understanding of physical models' characteristics in scientific research and recognizing their pivotal role in unravelling natural laws	Gain hands-on experience with constructing particle models, acquiring knowledge about the circumstances under which objects can be abstracted into particles within specific practical scenarios. Immerse yourself in the thought process involved in constructing physical models, fostering a deeper comprehension of this methodology.
Interaction and motion law	None or few	None or few	Learn the elasticity of objects through experiments	Learn Hooke's law through experiments
			Understand the law of sliding friction and static friction	Know the phenomena of sliding friction and static friction
			Use the synthesis and decomposition of forces to analyse life problems	Examine the issue of production and livelihood within the framework of equilibrium between concurrent forces
Mechanical energy and its conservation law	Qualitative understanding of elastic potential energy; Recognize the significance of	~~Illustrate with example that work is a measure of energy change.~~	Concerned about the magnitude and significance of common mechanical	Understand the magnitude and significance of common power

	incorporating the conservation concept in comprehending physical laws.	~~Through experimental investigations, delving into the correlation between work exerted by a constant force and the resulting change in kinetic energy.~~	power	
Curve motion and the law of gravitation	Through experiments, understand the curve movement, know the condition of the object to do curve movement; Through experiments, the law of horizontal projectile motion is explored and understood. To explore and understand the relationship between centripetal force of uniform circular motion and radius, angular velocity and mass	None or few	Use the method of motion synthesis and decomposition to analyse projectile motion	Experience the physical idea of decomposing complex motion into simple motion
Limitations of Newtonian mechanics and preliminary relativity	None or few	~~Know the experimental basis, basic principles and main conclusions of special relativity;~~ ~~A preliminary understanding of the main ideas of general relativity and the main observational evidence.~~		
Electrostatic field	Experience the scientific thought and methodology involved in exploring Coulomb's law; Comprehend the process of defining new physical quantities through ratios of existing ones;	None or few	Atomic structure	Atomic structure model
			Point charge	Point charge model
			Understand electric field strength	Know electric field strength
			Understand potential difference	Know potential difference

	Gain insight into the application and preservation of static electricity in production and daily life, while analysing charged particle motion within electric fields; Effectively explain relevant physical phenomena and observe capacitor charging and discharging phenomena.			
Circuit and its application	Understand the resistance characteristics of series and parallel circuits; Comprehend electrical work and power concepts; Demonstrate the ability to analyse and solve simple problems in household circuits, while applying knowledge of safe electricity consumption and energy conservation to practical life situations.	~~A preliminary understanding of the principle of multi-purpose meters;~~ ~~Logic circuits and integrated circuits.~~	Know Joule's law	Understand Joule's law
Electromagnetic field and electromagnetic wave preliminary	Recognize that light energy is discontinuous, with a preliminary understanding of the quantization properties observed in the microscopic world.		Understand the conditions under which induced current is generated	Know the conditions under which induced current is generated

Table 4.7

The changes of optional compulsory content in physics curriculum between version 2003 and 2017

Themes	Additions	Deletions	Adjustments	
			Old	New
Momentum and momentum conservation law			Understand momentum through experimentation	Through theoretical deduction and experiment, understand the momentum theorem
Mechanical vibration and mechanical wave		~~The Huygens Principle~~		
Light and its application		~~Observe the hologram with a laser~~		
Magnetic field			Calculate the magnitude of the Ampère force	Calculate the magnitude of the Ampère force in a uniform magnetic field
Electromagnetic induction and its application	Know the energy conversion during the operation of generators and motors	~~Through experiments, understand the conduction and hindering effects of 'capacitor' and 'inductor' on alternating current~~	Understand Faraday's law of electromagnetic induction	Understand Faraday's law of electromagnetic induction through experiments
			Know alternating current, use function expressions and images to describe alternating current	Through experiments, understand alternating current. Use formulas and images to describe the sinusoidal alternating current
Sensor	Know the physical meaning of molecular velocity distribution image			
Solid, liquid and		Know the meaning of Avogadro's		

Themes	Additions	Deletions	Adjustments	
			Old	New
gas		constant; Recognize that temperature is a marker of molecular average kinetic energy. Understand the concept of internal energy; Understand the microstructure of liquid crystals. To understand the main properties of liquid crystal and its application in display technology through examples; Know saturated vapor, unsaturated vapor, and saturated pressure. Understand relative humidity. Use example to illustrate the effects of the relative humidity of air on human life and plant growth.		
Law of thermodynamics		Preliminarily understand that entropy is a physical quantity that reflects the disorder degree of a system		
Atom and nucleus	Know the four basic interactions	Simply explain the reason why the number of neutrons and protons in light and heavy nuclei have different proportions; Know the conditions under which chain reactions occur. Learn how fission reactors work. Learn about the types of fission reactors commonly used. Know how nuclear power plants work		

Themes	Additions	Deletions	Adjustments	
			Old	New
Wave-particle duality	Understand the quantization characteristics of the microcosmic world. Experience the influence of the establishment of quantum theory on people's understanding of the material world	Know the Compton effect; Know that light is a probabilistic wave; Know the electron cloud; Initial understanding of uncertainty relationship	Through experiments, explain the wave-particle duality of light	Through experiment results, explain the wave-particle duality of light

From the changes in the specific content under the subtopics and themes, there were some differences compared to the old curriculum standards: firstly, due to time constraints, certain difficult and hard-to-understand topics have been removed from the compulsory and elective compulsory sections. This approach helps students better grasp fundamental knowledge and avoids excessively increasing their learning burden. For example, in quantum mechanics, the main principles of relativity and quantization are retained while eliminating specific content requirements, with some introductory quantum concepts moved to Elective Compulsory 3.

Secondly, the new curriculum standards have also adjusted the learning requirements for some concepts to adapt to modern educational principles and trends in technological development. In order to alleviate potential difficulties students may encounter in understanding certain concepts, the depth of comprehension required for electric field strength and electric potential difference has been simplified to a basic level of understanding. This design is beneficial for cultivating students' initial cognitive awareness of physics concepts and establishing a solid foundation for further in-depth research.

In addition, the new curriculum standards have also removed some experimental projects that are difficult to implement in schools or cannot be carried out due to limited resources. However, there is still an emphasis on the important role of experiments in understanding relevant concepts during the teaching process. For example, in the context of electromagnetism, there is a particular emphasis on using experiments to help students better understand important concepts such as Faraday's law of electromagnetic induction and electromagnetic oscillation.

Lastly, it is worth noting that the new curriculum standards have incorporated requirements regarding the core competency of physics. One of these requirements is the inclusion of modelling skills as one of the four elements of scientific thinking. Specifically, there are specific and high expectations for constructing particle models to promote students' understanding of modelling concepts and methods, as well as

cultivate their scientific thinking abilities. Additionally, emphasis is placed on guiding students towards a 'materialistic perspective' in physics education, enabling them to recognize the significant role played by matter in natural phenomena and interactions. This deep understanding aligns with the fundamental pursuit of unity theory within the field of physics.

In summary, in terms of course content, the difficulty of compulsory knowledge has slightly decreased but not significantly. There is a greater emphasis on experimental and practical processes in terms of content requirements, all of which are closely related to the curriculum objectives of cultivating and developing students' core competencies in Physics.

4.3.5 *Initial Comparison of New and Old Physics Textbook*

Due to the widespread use of the People's Education Press edition textbooks in China, this study primarily focuses on comparing the older version 'Experimental Physics: Ordinary High School Curriculum Standards' (2010 edition) with the newer version 'Physics: Ordinary High School Textbook' (2019 edition). The older version was initially released in 2004, and the 2010 edition is the third iteration of this textbook series.

Table 4.8

General comparison of two textbooks

	Old textbooks	New textbooks
Models	7	6
Number of Chapter	26	27
Number of classes	147	125
Content of chapter	Demonstration; Experimentation; Reflection and Discussion; Speaking and doing; Scientific exploration; STS (Science, Technology, Society); Questions and Connections.	Question; Demonstration; Experimentation; Reflection and Discussion; Scientific Method; Hands-on Experience; Scientific Exploration; STSE (Science, Technology, Society, and Environment);

	Extended Learning; Connection and Application; Review and Improvement.

Two versions of the textbooks both adopt a layout with modulars and covering topics such as mechanics, electromagnetism, thermodynamics, optics, atomic physics, etc. However, the 2010 version has many ‘major chapters’ like ‘conservation of mechanical energy,’ ‘electric field,’ ‘steady electric current,’ etc. In the 2019 version, teaching content has been integrated and certain sections with high difficulty or non-core content have been removed or split into smaller chapters. For example, in Compulsory Module 3, the 2019 version integrates the contents of ‘magnetic field,’ ‘electromagnetic induction,’ ‘electromagnetic waves,’ and ‘quantization of energy’ from the 2010 version textbook. Additionally, it splits the chapter on ‘electric field’ into two separate chapters: one on its applications and another on energy within an electric field. This approach describes electric fields from both a perspective of force properties and energy properties. With these measures in place and roughly similar number of chapters retained, there is a reduction of 22 lessons achieved to make the chapter content more concise. Such handling effectively lowers teaching difficulty while reducing students' learning burden.

The 2019 edition of the textbook has removed the 'Speaking' section from the 2010 edition and added four new sections: 'Questions,' 'Scientific Method,' 'Expanded Learning,' and 'Review and Improvement.' The sections 'Practice and Application' and 'STSE' in the 2019 edition are essentially similar to the 'Questions and Exercises' and 'STS' sections in the 2010 edition.

The purpose of the new 'Questions' section is to create a scenario at the beginning of each lesson that stimulates students to think about a specific problem, fostering their awareness of questioning skills. This aims to enhance their ability to raise questions, while guiding teachers to conduct teaching activities using a group-based approach focused on problem-solving.

The section on ‘Scientific Method’ provides an overview and summary of commonly used scientific ideas and methods in physics, serving as an effective

supplement to these concepts discussed throughout the text.

'Expanded Learning' primarily focuses on expanding knowledge by utilizing sensors, computers, and other devices for recording and processing data. This feature is designed for schools with suitable resources where students can choose additional learning opportunities.

At the end of each chapter, there is a dedicated set of exercises called 'Review and Improvement.' These exercises are divided into Group A (easier difficulty) which effectively reinforces fundamental knowledge and basic methods; Group B (higher difficulty) presents new scenarios often derived from real-life situations but requires constructing appropriate physical models using correct physics principles.'

Physics experiments, illustrations, sample problems, and exercise.

Physics is a experimental-based natural science, where experiments play a crucial role in physics education and serve as an important form of scientific inquiry. Both versions of the textbooks emphasize the teaching of physics experiments. In the 2010 edition, demonstration experiments are almost half as many as student experiments, highlighting the guiding role of teachers. However, there are fewer required student experiments. On the other hand, in the 2019 edition, there has been a significant reduction in demonstration experiments while increasing student group experiments, especially compulsory ones which have nearly doubled compared to before.

Table 4.9

Physics experiments, illustrations, sample problems, and exercise

	Old textbooks	New textbooks
Demonstrative experiments	52	33
Student experiments	33	37
Compulsory experiments	14	21
Illustration	1102	1345
Sample problems	49	45
Exercise	591	884

In the 2019 edition textbook, student experiments only provide students with ideas for experimentation. Students should discuss within their groups about 'what needs to be explored through the experiment, what physical quantities need to be measured, what

tools or methods should be used for measurement, and how to handle experimental data and analyse experimental errors.' This process emphasizes students' active participation in experimental teaching and aligns with the goal requirements stated in curriculum standards regarding fostering students' scientific thinking and abilities for scientific inquiry.

In addition, while the total number of chapters has decreased, a comparison between illustrations and post-exercise questions reveals a significant increase in their overall quantity. The 2019 edition textbook places greater emphasis on the use of illustrations, incorporating numerous real-life photographs to provide students with an intuitive understanding of the fascinating world of physics and enhance their interest in learning. The selection of illustrations highlights authenticity and strives for scientific accuracy and contemporary relevance. In terms of exercise backgrounds, the 2019 edition prioritizes creating physical contexts that are more closely aligned with everyday life situations, placing greater emphasis on applying physics methods.

Therefore, the new textbook also sets higher requirements for teachers. Teachers should be able to conduct experimental teaching while grasping the overall situation and recognizing the importance of experimental teaching throughout the entire teaching process. In the process of experimental teaching, teachers need to control the pace of the classroom, inspire students' thinking, integrate experiments with conceptual teaching, not only improve students' knowledge level but also enhance their practical abilities. Especially through experiments, students' core competencies in physics should be cultivated.

4.3.6 *Curriculum evaluation system*

The previous physics curriculum standards only provided suggestions regarding curriculum evaluation. However, in the 2003 edition of the physics curriculum standards, recommendations were made specifically about student assessment, emphasizing that evaluations should align with the objectives of the curriculum and focus on the following aspects.

1. Emphasize the role of evaluation in promoting student development, rather than focusing on its function for selection and screening.

2. Value the assessment of learning processes, instead of relying solely on exam results as the sole basis for evaluation.

3. Include students' performance in activities, experiments, projects, and explorations within the scope of evaluation, rather than relying solely on written exams as the only means of assessment.

4. Advocate for objective documentation of specific facts during students' learning process, without excessively emphasizing standardized evaluation criteria.

5. Teachers should transform their role from being judges in student learning evaluations to becoming facilitators and collaborators in student learning, guiding evaluations and developing students' potential. Encourage multiple stakeholders in evaluations.

6. Students should participate in evaluating their own learning process through self-assessment and peer assessment among classmates. (MOE, 2003, p. 52)

Compared with the old curriculum standards, in addition to retaining these suggestions, the new curriculum standards have added content such as ‘academic requirements,’ ‘academic quality,’ and ‘level division of core competencies in physics.’ The new curriculum standards describe and require learning, teaching, and academic levels from multiple aspects such as ‘curriculum objectives,’ ‘content requirements,’ ‘academic requirements,’ and ‘academic quality levels.’ This forms a complete system for guiding student learning and evaluation. Compared to the suggested attempt in the old curriculum standards, it establishes a more comprehensive curriculum evaluation system.

In order to make the requirements for core competencies in physics more explicit, the new curriculum standards propose five levels of proficiency (Appendix). These levels of core competencies are based on ‘content requirements’ and ‘academic requirements,’ particularly the foundation laid by ‘academic quality level.’ According to the requirements of core competencies, in order to be more specific and clearer about students' learning outcomes, the new curriculum standards provide academic requirements after each module. The academic requirements for each module are what

students should achieve after completing that module, and they specify what level of ability students should reach from the perspective of core competencies. The academic requirements only provide a unified standard for what level of ability students can achieve after completing this module; they do not give specific proficiency levels. Therefore, they can serve as a basis for evaluating students' academic performance but cannot be used as precise measurements or standards.

To provide a comprehensive evaluation of students' completion of high school physics courses, the new assessment system sets requirements for the 'academic quality' of their learning. It introduces a five-level scale called 'academic quality levels' (Appendix), which serves as the standard for assessing academic performance. The academic quality standards primarily focus on subject core competencies and their corresponding performance levels, considering the curriculum content to provide an overall description of students' academic achievements. The academic quality levels serve as both the basis for daily teaching and selection exams. Academic Quality Level 2 represents the minimum requirements that high school graduates should meet and serves as the basis for qualifying examinations in terms of academic proficiency. Academic Quality Level 4 is used as a criterion for entrance exams at higher education institutions, serving as a measure of students' academic proficiency.

Table 4.10

Suggested formative assessment methods comparison

	Suggested formative assessment methods
Old assessment	The physics teacher should adopt a variety of open-ended assessment methods throughout the entire process of education and teaching, such as written exams, experimental operations, research projects, behavioural observations, growth record files, and performance evaluations in activities to assess students.
New assessment	Daily learning assessment primarily evaluates students' level of competencies and comprehensive abilities demonstrated during their everyday learning process. There are typically four methods for daily learning assessment: classroom question and answer, written comments, self-evaluation, peer evaluation, and periodic tests.

Finally, both the new and old curriculum evaluations emphasize the importance of formative assessment. In the new curriculum, there is an added component of designing

evaluation tasks, which requires teachers to assess students' real learning environment based on their individual differences and the stage of the course, according to physics core competencies and academic quality levels. Evaluation and testing should also focus on student feedback and explanation processes, with timely communication of evaluation results to students. This not only helps students develop but also constantly adjusts evaluation content and task design.

4.3.7 *Discussion*

As a guiding document, curriculum standards serve as the fundamental guidelines for national curriculum. They establish the basic norms and quality requirements for foundational education courses, and provide the basis for textbook development, teaching, assessment, and exam formulation. Furthermore, they form the foundation of national curriculum management and evaluation. The old curriculum standards reflect the fundamental requirements in terms of knowledge and skills, processes and methods, emotions, attitudes, and values for students at different stages. They specify the nature, objectives, content framework of each subject curriculum while offering teaching and assessment suggestions. The new curriculum standards have updated various aspects of the old ones while also focusing on cultivating and developing students' core competencies concepts. By comparing them side by side one can observe the direction in which new curricula are evolving and changing.

Firstly, the new curriculum standards propose the development of students' core competencies as a new curriculum objective. From the analysis of the texts of both old and new curriculum standards, it can be observed that there is an inheritance in terms of connotation from three-dimensional objectives to core competencies. Core competencies are refinement and integration of the specific content for quality education that needs to be achieved through three-dimensional objectives. The three-dimensional objectives reflect the approach to achieving quality education, while core competencies define the content and direction for achieving quality education. At the same time, the establishment of a curriculum evaluation system revolves around

developing students' core competencies as a curriculum objective. This to some extent reflects the ambition of the new curriculum reform, which aims to achieve subject evaluation based on core competencies through comprehensive evaluation systems instead of purely exam-based evaluations, truly realizing educational reform aims and objectives.

Secondly, the introduction of subject-specific core competencies in the new curriculum is more characteristic compared to the previous three-dimensional curriculum objectives. For example, in physics core competencies, it can include both the scientific spirit and scientific thinking that are common to all science disciplines, as well as specific concepts such as materialism and energy based on the characteristics of physics. This concrete manifestation based on disciplinary characteristics can help physics teachers better understand core competencies and apply them in teaching. It guides teachers to reflect on the comprehensive role of physics education in student development and why studying physics is important. However, transforming a comprehensive and inclusive system of core competencies into subject-specific ones may lead to teachers underestimating the cultivation of core competencies and instead focusing on imparting disciplinary knowledge and improving students' grades as indicators of curriculum reform effectiveness.

Finally, in terms of curriculum structure and content, emphasis is placed on both foundational and elective aspects. Compared to the old curriculum standards, there is a combination of compulsory and elective curriculum that prioritize the foundation of the curriculum. Although there is a trend towards reducing the difficulty of foundational components, overall changes in knowledge difficulty within the curriculum content are not significant. The main changes in textbooks can be seen from two perspectives: firstly, according to the requirements of the curriculum standards, there has been an inclusion of ‘emphasis on humanistic care and promotion of excellent culture,’ which adds illustrations and short stories to enrich scientific knowledge while emphasizing the history of physics and scientists' spirit. Secondly, by adding mandatory experiments

for students to undertake, it highlights the role of scientific inquiry in physics learning.

It should be emphasized that having ideas and measures does not automatically lead to the natural construction of a new academic evaluation system. Especially in high school, the terminal evaluation represented by the college entrance examination is not only related to education but also closely linked to the current social situation and cultural traditions. It is also closely related to the values of students, teachers, parents, and all members of society. Therefore, a thorough transformation of understanding towards academic evaluation is needed. All relevant parties need to work together on a unified foundation of values, persistently resolving potential contradictions arising from different needs and perspectives. Only then can a truly new evaluation system be established.

4.4 Summary

In this chapter, I analysed the national policy texts in the early stage of curriculum reform and summarized the political, economic, and social background of this curriculum reform. In response to research question 1a, the fundamental changes brought about by China's overall social transformation regarding establishing a market economy system, promoting political democratization and legal development, constructing a new social structure and power relationship have not only influenced substantive aspects of the curriculum such as changes in curriculum systems and basic institutions but also involved strategic and technical means related to curriculum technology fields like curriculum development and operation. It concerns ontological thinking within the political and social scope of curriculum reform, fundamentally shaking up and reconstructing educational concepts and culture. The aim is to reflect on fundamental issues concerning education and human development through repositioning of the curriculum.

By comparing the new and old physics curriculum standards and textbooks, some findings can address research questions 1b and 1c. Firstly, the curriculum objectives

have been reconstructed from the general three-dimensional objectives across disciplines to specific subject-specific core competencies. For example, in the field of physics, these competencies are divided into conceptual understanding, scientific thinking, scientific inquiry, and scientific attitudes and responsibilities. Each section has corresponding objective explanations. Secondly, from the structure and content of the curriculum, while emphasizing foundational compulsory content, the new curriculum also encourages the development of school-based elective courses to enrich their content.

In addition, based on the changes in course content and textbooks, the new curriculum places greater emphasis on experimentation and inquiry. It includes mandatory experiments and inquiry processes for students, while also highlighting communication expression and collaboration in scientific exploration. To avoid having students engage in superficial 'inquiry' following predetermined steps by teachers or textbooks, attention should not only be focused on physical facts that align with the inquiry hypothesis; rather, observation and collection of information contradicting expected results are also necessary. Teachers should encourage and guide students to solve real-life problems based on their core competencies in physics. For example, when designing specific activities or formulating work plans, students should be able to analyse the main factors influencing a problem as well as secondary factors. They should also be capable of breaking down complex issues into simpler ones and considering cause-and-effect relationships between things. The content changes in the new curriculum have placed higher demands on schools and teachers.

Finally, the establishment of a new student evaluation system based on subject core competencies requires teachers to not only understand the subject core competencies, but also design effective assessment tasks based on the stage of the curriculum and individual differences among students. Additionally, four types of formative assessments are recommended in the curriculum standards: classroom questioning, written comments, self-assessment and peer assessment, as well as

periodic tests.

Of course, these changes mentioned above are primarily focused on the intended curriculum. The actual implementation process of the curriculum requires efforts and support from both the school level and teacher level. In the next chapter, I focused on the feedback and experiences of school principals and teachers during the curriculum reform implementation process. While seeking answers to research question 2, I analysed the roles and responsibilities of school principals and teachers in curriculum reform implementation.

Chapter 5 Data Analysis of implemented curriculum

5.1 Overview

As described in the curriculum framework, the implemented curriculum is divided into two levels: school level and teacher level. In this chapter, data from principal interviews and teacher interviews are analysed. Qualitative data are collected from open interviews with school principals at school level and semi-structured teacher interviews in three regions of China: Tianjin, Zhejiang, and Chongqing.

5.2 Sampling of participants

Principals and teachers participated into this study were from schools in three regions of China: Tianjin city, Xinchang city, and Hangzhou city. Four science teachers from Tianjin city, three from Chongqing city, and twelve in Zhejiang province were selected for interviews. Teachers in Tianjin and Chongqing are from rural and urban schools. Because of the vast of Zhejiang province, teachers were selected from high schools in three cities: Hangzhou (provincial capital), Xinchang, and Wenzhou. Principal interviewees were from three schools in the three selected areas. A principal in a high school in China plays a vital role in the management of teachers and dealing with educational changes. Detailed information of participants can be found in Table 3.6 and Table 3.7.

5.3 Data Analysis of principal interviews

Principal interview data were collected through open questions started with two main aspects: school-based curriculum in this reform and comments on the new curriculum. Since each interviewed principal's responses varied, I have chosen to report

on each principal's answers separately based on the themes coded from their transcripts, and then compare and summarize them at the end.

5.3.1 *Principal One - Chen from Tianjin*

Chen is a male vice principal from a rural high school in Tianjin. He has taught geography for about fifteen years and become vice principal for five years. He needs to balance teaching and management.

Theme one: Changes at school level in this curriculum reform

Chen had a clear understanding of the new curriculum and its changes, therefore, he tended to make brief description of the changes but many feelings and experiences during this reform. Following extract is his description of this curriculum reform.

'The curriculum reform mainly affects Gaokao (the college entrance examination), so our school will pay more attention on discussing the new approaches in teaching and subject choosing. It promotes the new mode of "elective course and class" which is new for both students and teachers. The direction of the new curriculum reform is set, but it is not certain for each school and each student'

Chen considered that the main change of this reform was the assessment which has much influenced with students' final performance and college enrolment. These issues also affected the school's competitiveness with other schools at similar level. Chen then explained how students' final performance in Gaokao affected and his school's situation in this reform.

'In the current educational environment in China, the source of students basically determines the brand of a school and determines its results. Although some schools stress on their 'school training capacity' to show that they can improve students' performance by advanced school-running concepts and scientific and diverse teaching methods, parents and students still tend to choose the school with high enrolment rate on high level universities. Therefore, in this situation, as a principal, I have to put much effort on how to attract better performance students to my school and the enrolment rate becomes the deadline.'

Chen also expressed his personal view on cultivating students:

'The students who have been trained cannot fully reflect the development of the

students just by looking at their college entrance examination results. Because the college entrance examination results are only one aspect of students' ability. The college entrance examination results cannot show the comprehensive quality of students. After these children go to university and enter the society, the students' comprehensive ability will be revealed.'

Chen has dilemma on implementing the new policies and making them sense for teaching. He performed as a mediating agent between government and teachers. He had confidence on this reform because he agreed with the changes on letting students have more autonomy and student-centre class teaching with more experiments and group discussion. He showed positive perception on 'bold attempts' at curriculum reform.

Theme two: **Role of School Principal in Implementation Process**

As Chen described his dilemma on implementation of the new curriculum, the role of school principal is two-fold: one is to deal with the new policy and make the changes succeed at the level of school-based curriculum; the other is to show his leadership in teacher management. Firstly, Chen concerned that the new policy led to the imbalance of subject choosing because of parents' misunderstanding of the new policy. Therefore, his first task in implementation is to figure out the advantages and disadvantages of his school and determine its position in this reform.

I have always felt that although balance and fairness are now the main theme of our country's education, the country's demand for talents is still divided into levels. Objectively speaking, there are indeed differences in human potential. People with good potential deserve better development and should take on more responsibilities. It is impossible for us to ask everyone to lift weights, because some people are not born with this material. We should let people with potential do what they should do. Education is like this, so that different people can get different developments that suit them. This is as same situation as schools. My school is in rural area in Tianjin and can be generally ranked at the middle level. We should consider what kind of people we want to cultivate. For example, my school is strong at History, Geography, and Biology. Students tend to choose these subjects instead of Physics and Chemistry, which there were about 80% students choose Science subjects in the old curriculum.

The imbalance of choosing subject lead to the teacher allocation problem that

Physics teachers are excessive while History and Geography teachers are in shortage. For example:

'Aside from my administrative work as a principal, I need to teach three classes (two Grade one and one Grade three classes) because there are not enough Geography teachers. I know this situation is not only happening in my school but also other schools in my district.'

As the second role of a principal, Chen needs to exercise leadership in teacher management. The leadership is shown in teacher organization, group discussion for tackling with the issues, and set up direction of school's future development.

We have discussed many times with teachers of various subjects, and we have also held some seminars with some schools in Zhejiang Province to exchange experience and worked out a preliminary plan. This plan is a limited open course selection, to protect some subjects from being unavailable, such as Physics. There are also several 'packages' for students to choose from, such as 'Physics+Chemistry +Politics/Geography/Biology' and 'History+Geography+ Politics/Biology/Chemistry'. While ensuring our superior disciplines, we ensure the balance of various subjects.

Also, it is necessary to help parents understanding the new curriculum and school's cultivation plan. Chen stressed that family factors have obvious effects on students' choice.

'We would invite parents to participate in many lectures and seminars before school starts, so that parents can clearly understand the spirit and actual impact of this reform. At the same time, this is also conducive to the future work of teachers.'

At last, leadership on students can deliver the spirit and philosophy of school administration. Chen agreed to learn and respond as much as possible about the students' demands.

Since I teach three classes now, I have a closer relationship with students. I also set up the principal's mailbox to provide students with a platform for suggestions and opinions. I would respond as much as possible to students' comments. I attach great importance to establishing an intimate relationship with students and passing on the school's philosophy through this form.

Chen's experience as a school principal play the role of coordination, mediation, and organization. Although the students' test score of Gaokao is still the deadline of

Chen's school, he was willing to make much effort on exploring new strategies to balance the policy, teachers, students, and their parents. However, efforts made by the principal are easily overlooked because they are often seen as policy implementer and promoter by teachers and parents. Chen also concerns on some points of this curriculum reform.

Theme three: **Comments on the new curriculum**

Chen's worries with the new curriculum at school level are two-fold: one is unsuccessful experience from other schools; the other is older teachers in this reform. Firstly, Chen considered that this curriculum was not mature as a successful test, which reduce his confidence on implementing the new curriculum policies. The following extract shows his concern:

I was invited to study in a high school in Hangzhou last year. In communicating with its principals and teachers, they expressed concern about the prospect of this reform. They also think that this reform is too radical, so from the result it is relatively failed. Therefore, based on their experience, schools in the rural Tianjin generally adopt conservative strategies to implement curriculum reforms carefully.

Chen also worried with the experienced teachers in this reform from two reasons: one is that they may have difficulties with adapting to the new curriculum including the elective class and new textbooks. The other reason is their health condition. However, their teaching experience may provide valuable suggestions on implementation practice.

Experienced teachers are an important resource for schools. Their teaching experience can help novice teachers. However, the curriculum reform has increased the requirements for teachers, requiring more investment not only in energy but also in physical strength. I am more worried about the physical condition of the old teachers, but the current teachers in some subjects are lacking. So, at this point, it is for the curriculum reform.

5.3.2 ***Principal Two – Wang from Xinchang (Zhejiang Province)***

Wang is a male principal from Xinchang city in Zhejiang Province. His school is the best performance high school in Xinchang. The curriculum reform in Zhejiang has started since 2016.

Theme one: **Context of school**

When President Wang was interviewed, the first batch of graduates after the reform had already taken the college entrance examination, so his evaluation of the reform first focused on the impact of the reform on the college entrance examination. Due to the characteristics of the region and the school, the students in his school attach great importance to the college entrance examination. The new model of subject selection and examination has brought great challenges to schools, students and parents. Here is President Wang introducing the basic background of his school.

Our school is the second ranked high school in Xinchang, and most of the students we accept are not enough students from the top high school, so the quality of students is not high enough, and the ability of students is not so outstanding, but there are still requirements for grades, and most students want to take the undergraduate exam. So, our school has always attached great importance to the quality of teaching. Since the curriculum reform, we have been actively cooperating with the above work, but we have indeed encountered many problems and challenges in our work.

Before facing these challenges, President Wang had exchanged experience with Jiangsu and other places. However, without a deep understanding of the core ideas of the new curriculum reform, the acceptance of it by schools, teachers and parents is still limited.

Before the curriculum reform, we also had some understanding of relevant research. The research conducted by East China Normal University also indicated that the reform was feasible and effective. That's why we proceeded with it. However, after going through one round of implementation, I still fail to comprehend the core spirit of the reform, let alone how concepts like core competencies are reflected in exam questions. The current reform seems to have shifted the responsibility for deciding a child's future onto parents, which I believe is problematic.

Nevertheless, under these circumstances, Principal Wang, along with several teachers and principals, provided feedback to the higher education authorities and expressed the difficulties faced by themselves and other educators. However, the higher education authorities insisted on implementing reforms without making any adjustments or delaying plans. This has made it even more challenging for Principal

Wang to advance educational work.

...After the policy implementation, issues raised by parents, teachers, and students are reported to the municipal authorities. However, despite this feedback, higher-level officials still demand that reforms be carried out in accordance with the policy and hold principals accountable for the progress of curriculum reform. When it becomes evident that reform is imperative, I tell my teachers to stick to our school's long-standing style. Let's not get too hung up on the curriculum reform theory. We should take our time on subject teaching content and focus on students' performance.

Therefore, Principal Wang lacked confidence in the new curriculum reform at the beginning. He may have been concerned about whether the new educational ideas and methods could truly enhance students' learning outcomes, as well as whether they would receive recognition and support from parents and society. Faced with this uncertainty, he may have felt confused and helpless. However, as a principal, Principal Wang deeply understood his responsibility to guide teachers and students towards the right direction.

Despite his negative attitude, he still adhered to his duties and actively fulfilled his obligations. In the process of reform implementation, Principal Wang might encounter various difficulties and challenges. Nevertheless, he did not retreat or give up; instead, while ensuring educational quality, he made efforts to find a suitable path for reform that suited the school's situation and actively promoted its implementation.

Theme two: **Reflection to changes**

Regarding the changes brought about by curriculum reform, Principal Wang pointed out two core issues: the impact on teacher arrangements and the influence on student choices. Firstly, the most obvious effect is a significant decrease in the number of students choosing physics as their subject, which directly results in great difficulties for teacher management. Principal Wang first elaborated on the reasons behind this change brought about by the reform.

I can understand why students don't choose physics. Firstly, in junior high school, a certain proportion of students will be streamed out and not go to senior high school. Those who are currently in senior high school are aiming to perform well in the college

entrance examination (gaokao), where their scores play a crucial role. Moreover, with the current scoring system based on ranking, it doesn't really affect top-performing students whether they switch to or continue studying physics. However, for average outcome students, they hesitate to choose physics because under this new scoring system, which assigns points according to rankings, their grades may decrease compared to before. For example, previously a student might have scored 80 points in physics but now it would only count as 70 points towards their total score. As a result, many students dare not select physics.

In this context, the surplus of physics teachers has become an unprecedented issue for schools. Although there are relevant contingency plans, such as temporarily transitioning to technical or administrative positions, it greatly undermines the enthusiasm of physics teachers. At the teacher level, negative emotions towards curriculum reform continue to accumulate.

Physics teachers have strong opinions about students not choosing physics, and I have also provided feedback on these opinions. However, the impact has been limited, so all I can do is reassure the teachers. This situation has a smaller effect on prestigious schools but undoubtedly has a greater impact on our ordinary school. Our job is quite challenging, but we can only endure for a few more years before making any significant changes.

In the other hand, the surge in the number of students opting for chemical biology has put a strain on the availability of biology and chemistry teachers. Concerned about the school's ability to manage this ever-changing demand for teaching resources, it is currently being suggested that students choose one subject between physics and history first, before selecting the remaining two subjects. This approach would effectively alleviate the pressure on teaching resources.

Furthermore, drawing from past reform experiences, Principal Wang believes that this reform will lead students to pragmatically avoid traditional science subjects with a focus on physics. He argues that this may result in a decrease in talent within the STEM fields, which could have profound implications for the country's development and societal progress. Additionally, due to an excessive number of students opting for chemistry and biology, there is a lack of differentiation in science scores, forcing

reliance on language arts and English as distinguishing factors. This contradicts the recruitment objectives of university science programs.

Let me put it this way, students definitely long for freedom and also desire to reduce their academic burden. Over the years, efforts have been made to alleviate the workload on students. However, they still cannot avoid the college entrance examination (gaokao). Even if a student has his own ideas, would his parents agree? But this choice of not selecting physics or chemistry is driven by utilitarianism rather than genuine interest. If there is a significant nationwide decrease in these subjects, it may adversely affect enrolment in science and engineering universities and even lead to job losses for professors in these fields. What will happen then to China's development in science, technology, and engineering? The current situation of educational reform shows that there is poor coordination between high school education and both higher-level education institutions above it and lower-level education below it; thus, making high school education seem out of sync.

Therefore, Principal Wang suggested during his communication with other school principals from different provinces and cities that it would be better not to allow students to choose their courses freely at the beginning of the reform.

'A former principal from the northern region asked me about the reform situation, and I always recommend them to adopt the '3+1+2' model. This means students can choose either physics or history, and then select their remaining subjects accordingly. This approach should prevent situations where physics teachers have no classes to teach. It also facilitates classroom arrangement and class management significantly. Currently, this is the most optimal solution we have summarized, especially for ordinary post-compulsory secondary schools.'

Theme three: **Accountability to education equity and teacher training**

Principal Wang visited a high school in Australia for exchange and communication in 2010, which led him to deeply reflect on education equity. Through conversations with Australian principals and teachers, he realized that there are still some issues affecting education equity in China.

There are still many urgent issues that need to be addressed in China, such as the unequal distribution of educational resources. Even within a province or city, students

cannot enjoy the same quality of education. This leads to a migration of students and teachers from underdeveloped provinces and regions to more developed areas. I am aware that China has made significant efforts to address regional imbalances, but there is still much room for improvement in the field of education.

Principal Wang believes that education reform should focus on two aspects: educational equity and teacher training. He firmly believes that only by achieving true educational equity, where every child can enjoy high-quality educational resources, can we promote social progress and cultivate talents.

Reform is indeed an opportunity for change, but it should not only focus on altering the format of exams or teaching methods. Traditional educational models have also produced many talented individuals. Through exchanges, I have gained a basic understanding of foreign models, and it is clear that we cannot simply replicate them in our country due to different national conditions in China. For example, how many students are there in a class abroad? Even with small class sizes in our schools, the number of students is definitely over 30, and some classes even exceed 50. A single wrong decision at the higher level can impact thousands upon thousands of students. As a principal, I am responsible for the well-being of my students and must uphold my conscience. In my view, the current reform seems to be blindly copying foreign models without much practicality.

Meanwhile, Principal Wang advocates for extending the duration of curriculum reform and integrating reform practices into everyday teaching. He believes that reforms should not be rushed, but rather gradually improved and yield better results through continuous implementation. Only by infusing reform concepts into daily classrooms can they truly enhance students' comprehensive abilities and innovation skills.

I think the reform cycle should be longer. For example, in developed areas, good schools could conduct one or two rounds of experiments first. When implementing it statewide, there should also be a buffer period to allow principals to understand the potential difficulties and carry out their work with a well-thought-out plan. The overall coordination of teacher positions can also be arranged in advance to prevent chaos caused by sudden reforms, ultimately avoiding any disruption to students' learning.

In addition, Principal Wang emphasized the importance of feedback mechanisms

in the process of reform. He believes that policy reforms should not be implemented solely from top to bottom, but rather should pay more attention to feedback provided by practitioners, especially principals and teachers. Only by listening to evaluations and suggestions from all stakeholders regarding reform measures and their effectiveness, and making corresponding adjustments and optimizations, can they ensure that the desired goals are ultimately achieved.

And another thing is the feedback mechanism. You may not be aware of this as researchers, but it's very difficult for us frontline educators to provide feedback on the shortcomings of curriculum reforms. In our schools, it's somewhat better, but in some lower-tier high schools, there are almost no students choosing physics anymore and physics teachers are being laid off. Can policy makers understand these situations? Can they address them? Currently, exams and teaching are two separate systems with administrative departments overseeing them. I feel like they have little connection to educational practice.

In Principal Wang's vision, the concept of ‘people-oriented’ is an essential core principle for promoting the development of education in China. By focusing on grassroots teachers' practices and addressing issues that affect fairness, strengthening teacher training, extending the cycle of curriculum reform, and valuing feedback from all parties involved, it is possible to strive towards educational goals that are more just, comprehensive, dynamic, and competitive.

Finally, as Zhejiang Province is one of the first regions to participate in the curriculum reform, it is not feasible for President Wang to quickly spread this model to the whole country. The problems in Zhejiang have not been well solved, and he does not quite understand why it is based on nationwide promotion.

Many people asked me about the experience of reform, and I said that there was no successful experience, only failure experience, and I would even say that this is a failed reform experiment.

5.3.3 ***Principal Three: Zhou from Hangzhou (Zhejiang province)***

During the interview, Principal Zhou had just been transferred from a high school in Wenzhou, Zhejiang Province to a high school in Hangzhou, so he had a good

understanding of the situation on both sides, but he was not particularly in-depth. Principal Zhou's interview mainly focused on the reform of the college entrance examination, and also talked about the strategic arrangement of the school in dealing with the new college entrance examination. At last, the author compares the differences and common difficulties in the construction of schools in Wenzhou and Hangzhou.

Theme one: **Reflection to curriculum reform and status**

President Zhou continues to pay attention to and understand the theory and policy of curriculum reform based on the development of core competencies. The following is his understanding of curriculum reform.

I have been paying close attention to the academic research and policy release in this field, and I understand the new requirements put forward by the state for students and teachers, such as the 'moral cultivation' mentioned in the document a few days ago and the emphasis on the cultivation of scientific competencies. I think it means that our country's education has entered a new era, and it needs to get rid of the exam-oriented thinking and pay attention to the cultivation of students' innovative thinking and critical thinking. This is my superficial understanding, I think the policy and theory are very good, and also conform to the development of society, but the practice of reform will certainly not be so idealized. As the saying goes, 'the top has the policy, the bottom has the countermeasure' (people have their own countermeasure to cope with government policy).

Contrary to the expectation of theory and policy, the practice of curriculum reform shows a stronger exam-oriented approach, and also produces many exam-oriented school strategies. Starting from the practice of curriculum reform, President Zhou also talked about the current situation of Wenzhou curriculum reform based on his own experience.

As for my former school in Wenzhou, the current core focus is still on how to assign scores in the college entrance examination, and how to make students get higher scores in the examination. For example, because the subject is now selected for a total of two examination opportunities, some secondary schools will first inquire about the examination arrangements of those good schools, hoping that their students can avoid these candidates, get a higher ranking, and achieve positive scoring. It feels a little out of the realm of education, but that's all schools can do for now.

Principal Zhou also believes that this strategy does not align with the long-term development orientation of the school, but rather serves as a temporary measure in response to the reform of college entrance examination.

Actually, many of these strategies are just meant to reassure students and parents, and they may not have much real effect. After all, how can so many schools possibly avoid the situation? However, because of these strategies, the teaching arrangements in many schools have become quite strange. There are even cases where subjects other than one are not taught at all, and all class hours are focused on intensive revision for exams. From my perspective, I am against this kind of short-sighted approach that sacrifices long-term benefits for immediate gains; it doesn't align with educational principles. Of course, such extreme strategies are not very common either, and I haven't heard of any good results from them. So we can only say that it's chaos during the early stages of reform.

Theme two: **Principal as lead learner**

Fullan (2016) concluded that principals affect all teachers by becoming 'the lead learner'. The principal, Mr. Zhou, also believes that as a school leader, one should not only have the role of a teacher but also play a guiding role while understanding the work of teachers. This is to promote the development of a comfortable teaching environment and research atmosphere for teachers.

I also grew up from being an ordinary teacher as anyone else, so I have been contemplating the transition from a teacher to a principal over these years. In my opinion, a principal should not just be a mere administrator but should play a leading role in teaching work. That's why I have always been involved in classroom teaching. I believe that principals who are detached from their roles as teachers find it difficult to truly gain the support of their staff, which can hinder the implementation of educational reforms and philosophies. For example, I want to enable teachers to truly reduce their workload and focus on improving their teaching skills while also engaging in research. By establishing an effective feedback mechanism for principals within the school, we can quickly understand the needs of our teachers and make rational use of resources.

Of course, my ideas may seem somewhat idealistic; that's why I sought a transfer from a school in Wenzhou to this newly established school in Hangzhou – because I wanted a place where I could fulfil my ambitions. Additionally, this new school will have many young teachers, making communication and collaboration more convenient.

At the same time, Principal Zhou believes that school leaders should also adopt a subtle leadership style to guide curriculum in their daily lives. This type of curriculum leadership does not involve much theoretical exposition or empty rhetoric from school leaders. Instead, they often influence teachers' behaviour and thinking through their own daily leadership actions, conveying a set of values and attitudes about what matters and what doesn't matter to teachers.。

For example, when encountering a young teacher in the hallway, show concern about their participation in academic conferences and encourage them to stay updated on curriculum reform. It is important for teachers to broaden their perspectives in order to excel at their job. Additionally, emphasize the importance of studying curriculum and teaching theories as they expand one's horizons and enable better adaptation to curriculum reforms. These actions help teachers prioritize theoretical learning. Another approach is to inquire about their thoughts on curriculum reform or teaching-related matters, making them feel that the principal consistently cares about their professional development and teaching performance.

Therefore, the curriculum leadership in schools operates through formal and informal means, with seemingly ordinary things quietly promoting school transformation and driving the school towards its predetermined goals. Curriculum reform is difficult and complex, but changing teaching and school conditions is not unattainable because these conditions exist in every classroom and school. The power of this transformation also exists within the daily operations of the curriculum organization led by principals.

Theme three: **Comparison between Hangzhou and Wenzhou during reform**

In the final part of the interview, Principal Zhou talked about his experience since coming to Hangzhou. He believes that as the capital city of Zhejiang Province, Hangzhou has abundant educational resources. However, this also means that there is more competition among students for these high-quality resources. As a result, students in Hangzhou not only have enriching academic pursuits but also enjoy a fulfilling extracurricular life.

After coming to Hangzhou, I truly feel the city's modern development. As a

renowned tourist city in China, Hangzhou has always emphasized the harmonious coexistence of people and nature. Similarly, it is also at the forefront of educational reform nationwide, not only focusing on students' academic achievements but also requiring them to have rich extracurricular activities and diverse interests. For instance, I once met a student who was a member of the championship team in a robotics competition, mainly responsible for programming. When I asked him when he started learning programming, he said it was during his childhood when he developed a special interest in robots. Encouraged by his teachers, he participated in preparations for the robotics competition. Combining interests with learning is indeed the best way to study.

From Zhou's experience, transitioning from management to leadership is a trend in the development of school leaders. Of course, both management and leadership are equally important for schools as they are necessary for maintaining normal operations. Although there are differences between leadership and management, they are both crucial. An excessive focus on management without adequate leadership can ultimately result in the loss of spirit or goals within an organization. On the other hand, even with charismatic leadership, an organization with poor management may experience temporary rapid growth but lead to fail. The essence of transitioning from management to leadership lies in eliminating the shortcomings of traditional management and creating an atmosphere that is more conducive to curriculum reform in schools, rather than negating the concept of management.

5.3.4 ***Discussion***

The expressions of three principals reflect their different attitudes towards curriculum reform and their different feedback as leaders in implementing curriculum reform. Faced with educational changes, principals demonstrate varying mindsets. If I analysed from the dimensions of participation level and response mode, principals' attitudes towards reform can be divided into four types: 1. Principals may respond actively to reforms but still implement them according to the original methods; 2. Principals resist reforms and continue to follow their own ways in practice; 3. Principals hold an optimistic attitude towards change and actively promote it during

implementation; 4. Principals are forced to respond and participate in curriculum changes due to external pressures.

Principal Chen belongs to the first type, as he has his own thoughts on curriculum reform but did not deeply engage in reforms based on local policies in Tianjin and experiences from Zhejiang's reforms. Principal Wang undergoes a transition from the second type to the fourth type after experiencing three or four years of reform. Due to a negative attitude towards curriculum reform, he returns his focus on exam scores while largely ignoring the impact brought by reforms. Compared with the previous two principals, Principal Zhou, after experiencing initial chaos during the early stages of reform, transitions into a new school where he can express his ideas freely. He attempts to interpret new curriculum reforms from a perspective of curriculum leadership and seeks new development paths for school-based curricula.

Therefore, moving towards curriculum leadership is an inevitable trend for principal roles and functions transformation during curriculum changes. In today's context where curriculum management takes precedence, curriculum leadership has quietly emerged and manifested itself through principals' unintentional behaviours.

There are two sets of curriculum leadership organizations in schools: one is the ‘formal’ organization, and the other is the ‘substantive’ one. The newly established curriculum leadership organization mainly serves the purpose of external display, while the existing teaching leadership organization fulfils its true responsibilities. This seemingly contradictory but harmonious and well-defined dual structure has attracted attention, which not only depends on how principals utilize these leadership organizations, but also reflects their underlying thoughts and beliefs. The existing teaching leadership organization has always played an important role in schools and is based on management principles, possessing indisputability in the teaching process. Although this system has shown a trend towards flattening, control and management still dominate mainstream thinking. Due to excessive reliance on an organizational structure with a strong inclination towards management thinking, the practice of ‘*putting new wine into old bottles*’ limits its effective functioning. There may have two main reasons for the formation of this phenomenon where there are two layers to

curriculum leadership organizations.

On one hand, the reason is that the higher-level supervisory departments have overlooked the actual situation of schools. In the process of implementing reforms, they would not consider the actual conditions of schools. They would assume that as long as schools established corresponding curriculum leadership organizations, the implementation would definitely be effective. Under this kind of thinking guidance, schools universally established new curriculum leadership organizations. For schools, these newly established institutions are somewhat awkward in their position and have little practical effect. However, if they are set aside, it would be seen as not meeting the requirements of curriculum reform policies. Furthermore, it is difficult for these new curriculum leadership organizations to fit into the existing organizational structure of schools, and it is impossible for schools to break their already formed fixed systems. In this situation, schools can only make do with what they have and continue using their original leadership organizational structures.

On the other hand, it depends on the personal beliefs of the principal. The concept of management is deeply ingrained in their minds, while leadership as a new concept is still relatively unfamiliar to them. Therefore, despite the emergence of new curriculum leadership organizations, principals still find traditional methods more effective and easier to implement. The new curriculum leadership organizations can only remain at the level of written curriculum. If reforms are necessary, principals tend to adjust existing teaching leadership organizations rather than consider new curriculum leadership organizations. The neglect of school conditions by higher authorities and the influence of personal beliefs held by principals have resulted in a superficial implementation of curriculum leadership organizations.

From findings from the principal interview, it was found that principals' curriculum leadership still remains constrained by traditional management thinking. Control continues to be the main strategy and management remains mainstream in the process of principal curriculum leadership. This control is not only reflected in educational philosophy and organizational management structures but also evident in school curriculum planning, implementation, and evaluation. Its primary manifestation

in practice is a lack of trust, where everything needs to be done personally. The reasons for this lack of trust may include the following:

The first possible reason is that middle-level leaders and teachers in schools are relatively powerless and unable to assume their leadership responsibilities. As a result, principals who are responsible for leading curriculum reforms are forced to take on management duties. Due to their strong personal abilities and the relative weakness of other groups, this leads to a reality where school administration relies heavily on the capabilities of individual principals. The dependence on principals can easily lead to excessive concentration of power and control as the main means of leading reform.

The second reason is the assumption society holds about the traditional role of principals. Many principals and teachers believe that ‘a good principal equals a good school.’ A good principal indeed promotes school development. However, from another perspective, excessive reliance on principals, even treating all matters within the school as solely under their jurisdiction, provides an excuse for some individuals within the school to shirk responsibility. At the same time, it also offers a reasonable explanation for excessive centralization of power by principals and their over-control of schools.

The final reason is the existence of traditional management methods in many schools, especially rural ones. Traditional school management adheres to a linear approach where everything follows predetermined procedures. For leaders, however, it becomes difficult for them to grasp and adapt due to emphasis on dynamism and changeability. Even with leadership thinking in place, they unconsciously or consciously revert back to management during actual operations by employing controlling methods as part of their leadership style. Due to these reasons mentioned upon, curriculum leadership carries strong managerial characteristics.

Therefore, due to the narrowness of the principal's curriculum leadership group, although there is a trend for the organizational structure of course leadership to move towards a collective body consisting of principals and most teachers, the scope of leadership groups in China's current school life is still relatively narrow. Principals and middle-level leaders are the main body of curriculum leadership, while teachers and students are largely excluded from leadership. The phenomenon of a narrow leader pool

stems partly from people's understanding of leadership. Leadership is often associated with corresponding positions and levels of power; without a position, one cannot be considered a leader. This excludes ordinary teachers and students from the leader pool. On the other hand, influenced by role differentiation in schools, principals are seen as leaders while teachers are followers and students as learners. When this role differentiation is established in relation to leadership, principals are considered 'legitimate' leaders while teachers and students become followers. The narrowness of the leadership group not only burdens leaders with excessive responsibilities but also affects democratic decision-making within schools. When their decisions to some extent conflict with the ideas of teachers and students, it may obviously hinder the implementation progression of the curriculum reform.

5.4 Teachers Interview Analysis

5.4.1 *Overview and Samples*

Four science teachers in Tianjin, three in Chongqing, and twelve in Zhejiang were selected for interviews. Teachers in Tianjin and Chongqing are from rural and urban schools. Because of the vast of Zhejiang province, teachers were selected from high schools in three cities: Hangzhou (provincial capital), Xinchang, and Wenzhou. Table 5.1 shows the detailed characteristics of selected teachers and schools.

Table 5.1

Teacher and school characteristics

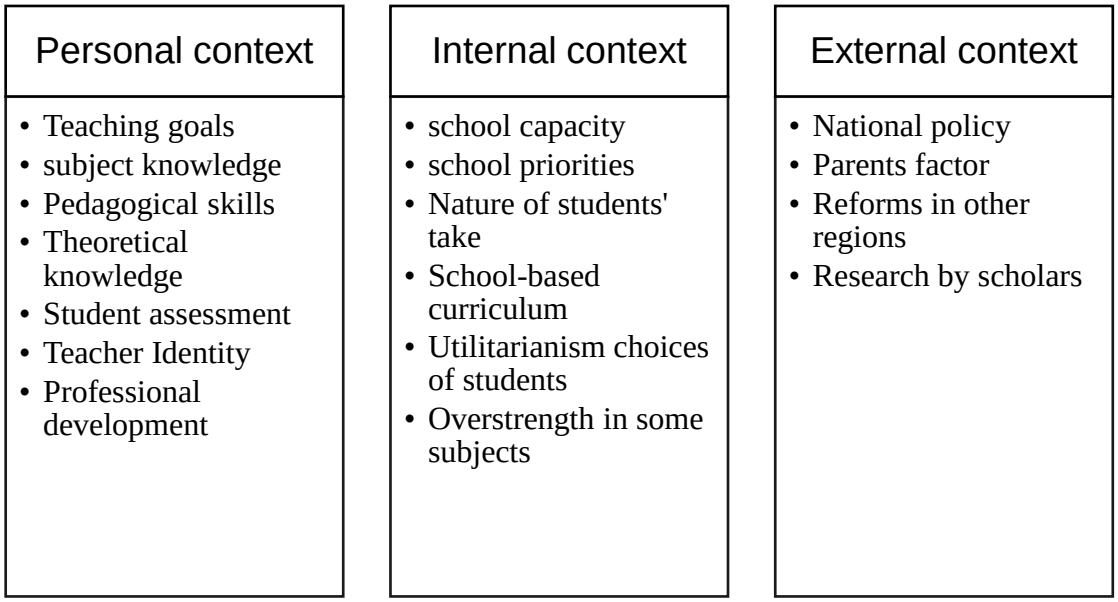
Teacher label	Response to reform	Gender	Subject	Years in teaching	Grade	School age range
T1	Negative	Male	Biology	12	3	13-18
T2	Negative	Male	Technology	15	2	16-18
T3	Positive	Male	Physics	4	1	13-18
T4	Positive	Female	Chemistry	3	1	13-18
C1	Negative	Male	Physics	10	2	13-18
C2	Positive	Male	Physics	9	2	13-18
C3	Negative	Female	Chemistry	10	1	13-18
Z1	Neutral	Female	Physics	13	1	16-18
Z2	Positive	Male	Chemistry	18	2	13-18
Z3	Negative	Male	Physics	27	1	13-18
Z4	Negative	Male	Physics	7	2	16-18
Z5	Neutral	Male	Physics	3	1	13-18
Z6	Negative	Female	Physics	27	1	13-18
Z7	Neutral	Male	Physics	19	1	13-18
Z8	Positive	Female	Chemistry	2	1	13-18
Z9	Neutral	Female	Biology	16	3	13-18
Z10	Positive	Female	Chemistry	11	3	13-18
Z11	Neutral	Female	Chemistry	20	3	16-18
Z12	Neutral	Male	Physics	21	1	16-18

T for Tianjin, C for Chongqing, Z for Zhejiang. Each number stands for a specific teacher interviewed.

This section of the study is based on the analysis of three contexts: Personal, Internal, and External. The detailed themes are presented in the accompanying figure

Figure 5.1

Personal, internal and external contexts of teachers' experience



5.4.2 ***Data Analysis from Teachers Interview***

In the process of coding and analysing transcripts, I found that the interview content and themes include not only teachers' own feedback but also feedback from other participants and influencing factors in curriculum reform. Therefore, to reflect the characteristics of teachers' responses and reflections systematically, the analysis emphasizes presenting teachers' viewpoints from personal, internal, and external context. Firstly, the first theme focuses on teachers' feedback regarding changes on teaching goals, teaching methods and student assessment, highlighting their different expectations and initial reactions to curriculum reform. The second theme emphasizes the impact of curriculum reform implementation on teacher identity and roles in teaching. Building upon these two sections, the third theme mainly analyses internal influences at a school level including school capacity, school priorities, and school-based curriculum on teachers' professional development. The fourth theme examines teachers' feedback on the impact of curriculum reform on students.

Theme one: Personal reflection to changes on teaching goals, teaching methods, and examination formats

When it comes to the curriculum reform, teachers generally believe that it is most closely related to the reform of Gaokao (college entrance examination). They point out that with social development and changes in educational concepts, the traditional college entrance examination system can no longer fully meet the needs of modern students. Therefore, in this curriculum reform, adjusting the format of the college entrance examination is considered crucial. Teachers in Chongqing have expressed their expectations and experiences regarding the reform when discussing curriculum changes.

> *If you ask me what has changed the most in the new curriculum reform, it would definitely be the college entrance examination (gaokao), as it serves as a compass for educational trends. As frontline educators, we are particularly sensitive to these changes because they have a significant impact on our teaching plans. Therefore, we pay close attention to what new changes will occur this time. Based on my experience, which may not be entirely accurate, there might not be substantial changes in the subject content of gaokao. However, alterations in the overall examination and admission system will greatly influence the formulation of our teaching plans; everything needs to be rethought and redesigned. (C2)*

However, not all teachers focus solely on the format of the college entrance examination. Some teachers believe that attention should also be given to changes in teaching objectives and teaching methods during curriculum reform. They emphasize the importance of cultivating students' innovative thinking, practical abilities, and spirit of cooperation. These teachers believe that by introducing more interactive, exploratory, and practical content, students' interest and enthusiasm for knowledge can be stimulated, while enhancing their problem-solving skills and ability to face challenges.。

> *I think the changes made are quite good. The previous teaching method was more focused on exam-oriented learning, which didn't do enough to cultivate students' interest in learning and innovation. It is definitely necessary for them to develop these abilities for future success in society. Merely studying hard is not enough; they need to apply what they learn actively. (T3)*

It is worth noting that when evaluating this reform, most teachers tend to discuss it from their own experiences and teaching practices, with less emphasis on theory or macro-level perspectives.

This may be because they are more concerned about how to implement new policies and adapt to new requirements at the operational level. It also reflects their sense of responsibility for their own roles and attitudes towards students' growth and development. For example, interviewed teachers in Zhejiang believe that the impact of the reform on teaching content is not significant, at least there have been no major changes at the level of teaching content.

> *My years of frontline teaching experience have taught me that during reform years, everyone lacks experience. As a teacher, it is important to focus on the content of instruction and minimize the impact on students as much as possible, allowing them to concentrate on their studies. For example, subjects like kinematics and electromagnetism haven't undergone significant changes, so we continue to teach them in the same way as before. Of course, our school is a key institution in the city with high expectations for academic performance. Additionally, our students have a strong foundation and good learning attitudes; I believe they adapt faster than students from other schools. (Z12)*

From the responses of teachers who hold positive and neutral attitudes towards the current state of reform, several characteristics can be observed. Firstly, teachers who are supportive of curriculum reform generally believe that changes in the college entrance examination (gaokao) are decisive and that the current student evaluation methods are relatively narrow, particularly with regards to changing the past trend of excessive exam-oriented education. Secondly, teachers with a neutral stance tend to possess a good grasp of the core aspects of curriculum reform and their students also demonstrate stronger adaptability. For instance, Z12 teachers' school is a key high school in Hangzhou City, which has sufficient educational resources to balance both reform and academic performance. Lastly, teaching objectives still focus on curriculum content learning and academic achievements.。

Apart from the viewpoints mentioned before, there is also a portion of teachers who hold a negative attitude towards the reform. They believe that although the college entrance examination system has problems that need to be changed, the reform would trigger various negative issues and impose a heavy burden on teachers. Firstly, the increase in teaching objectives based on cultivating students' core competencies makes it difficult for teachers to comprehend the direction of the new curriculum reform, especially for older teachers. For instance, C1 teacher from a key school in Chongqing currently exchanges teaching positions with non-key schools in Chongqing as one of

the necessary conditions for promotion among key school teachers exchanging positions with non-key schools.。

The new policy has two aspects of impact on teachers' work. On one hand, there are updates in teaching content, which poses challenges for many older teachers to adapt to the new materials. On the other hand, there are significant changes in class scheduling compared to before, and the cancellation of separating students into science and liberal arts classes as well as the advancement of college entrance examination also add difficulties in arranging teaching content. Overall, teachers who have been accustomed to the traditional teaching mode for many years, including myself, have a strong resistance towards the current curriculum reform. This resistance may mainly stem from our reluctance to change because both textbooks and teaching progress and time have undergone alterations that require teachers to adapt first. (C1)

For this teacher, in the new mode, due to the need for adjustments, arrangements, and organization in every class, as well as time constraints, there is a shortage of teaching hours. This makes it difficult for teachers to fully impart knowledge and provide in-depth explanations within limited time. Moreover, in fast-paced teaching sessions, the focus often lies on test-taking skills and organizing key points rather than cultivating higher-level abilities such as critical thinking and innovation awareness among students.。

Due to the fact that classes are conducted in different classrooms, which are not fixed, there is still a relatively large number of students per class in China. Even in small-scale classes like ours, there are at least 30 or more students. Just imagine, after each class ends, over 30 students carrying their backpacks have to walk to different floors. This wastes a considerable amount of time. Another issue arises as well - forgetting some biology lessons can take up the entire 45 minutes of class time. Currently, I don't even have enough content to fill up the full 45 minutes because students from different classes arrive at the same classroom at different times; some early and some late. Therefore, by the time everyone from one class gathers together, sometimes already five minutes of class time has passed. This phenomenon didn't exist before but ever since we started rotating classrooms for each subject, it takes a long time just for students to enter the classroom itself. Moreover, we cannot extend our lesson beyond its scheduled end time because it may affect other classmates who need to use this room for their next lesson. So, we can neither start on time nor run overtime during teaching practice compared to before. (C1)

Teachers in Zhejiang Province also have their own experiences with this phenomenon.

Regarding the issue of having teachers with an unpredictable schedule, it also affects the concentration of students. When students come from different places and gather in one room, they may engage in conversations even after sitting down. It takes a few minutes for them to settle down and get into the right mindset. Therefore, there will be some impact on their energy levels. (Z3)

In addition, it has been found in practice that there is already a problem of inadequate educational resources in rural or economically underdeveloped areas. If the elective rotating class system is implemented, it would further exacerbate the phenomenon of resource concentration in high-quality schools in cities and result in brain drain for rural schools. A physics teacher from a non-key middle school in Zhejiang province emphasized the need to pay special attention to the impact on underdeveloped areas during the reform.

In our region, we are not particularly affluent compared to the rest of the province. In recent years, we have been facing issues with teacher attrition. To be honest, our school does not have the resources to implement a rotating class system. Even if we were to make changes, it would only be superficial and I believe it wouldn't yield much effect. We are currently voicing our difficulties to higher authorities, but I think our main challenge lies in the insufficient teaching staff. Good teachers naturally aspire to work in prestigious schools, so those who remain at our school usually lack motivation for reforms. (Z4)

Several characteristics can be observed from the responses of teachers who hold a negative attitude towards the current state of reform. Firstly, these teachers lack preparation for curriculum reform and find it difficult to adapt to sudden changes in their teaching habits. Due to uncertainty about future development, they easily develop doubts and resistance towards the reform. Secondly, regional disparities in development also lead some teachers to believe that the reform further widens the gap in already unevenly distributed educational resources. Lastly, as practitioners primarily focused on practical aspects, these teachers find it challenging to deeply comprehend the theoretical foundation of curriculum reform. For instance, very few references are made to core theories such as 'core competencies' in their responses.

Therefore, in the process of reform, all factors should be comprehensively considered, and corresponding measures should be taken to address potential issues. For example, the reform can be gradually implemented while ensuring a balance between imparting fundamental knowledge and fostering personal development to alleviate teachers' workload. Simultaneously, efforts should

be made to enhance the allocation of quality educational resources and support policies in rural and economically disadvantaged areas to ensure that the principles of fairness and justice are reflected throughout the entire reform process.。

Theme two: Teacher Identity and roles in teaching.

Curriculum reform is not just about adjusting teaching methods and designs, but more importantly, it triggers teachers to deeply reflect on their professional identity and the essence of education. In this process, most interviewed teachers agree on one point: a teacher's identity in teaching is not fixed, but rather diverse and developmental. For example, the following teacher quotes from the classic Chinese educational work 'The Discourses of Master Teachers' to answer questions about teacher identity.

> *If we talk about the role of a teacher, it is like the traditional Chinese education concept of being a 'guide who imparts knowledge and resolves doubts'. In my opinion, teachers should not only teach students knowledge but also help them learn how to learn. This includes cultivating good study habits as well as teaching proper behaviour and morals. Teachers have a responsibility in all these aspects. (Z11)*

This presents teachers with a dual role of imparting knowledge and cultivating morality, indicating that such teachers not only focus on the growth of their own teaching abilities but also have requirements for their own moral standards. This aligns perfectly with the traditional Chinese value of respecting teachers and emphasizing ethics. However, from the perspective of teachers who prioritize students' academic performance, the teacher's identity primarily lies in being the leader in classroom instruction.

> *The teacher is the leader, the core of education. It has been emphasized for a long time that students are the focus, but this is incorrect. If a teacher cannot control the course as a whole and instead relies on catering to individual student preferences, it becomes challenging when dealing with diverse ideas from thirty or forty different students. If students are considered the main focus, each student's unique characteristics would make it difficult to find common ground. In my opinion, an excellent teacher should maintain consistency in their teaching content while adjusting difficulty levels based on individual students' needs. The core of educational content should not change because if it does... (...) Teaching is like a tree; its trunk must remain intact. If the trunk breaks, then the entire teaching process becomes meaningless. (C1)*

A teacher with 27 years of teaching experience in the field of physics stated that science teachers should not only impart knowledge but also engage in research work within their own domains.

> *I have been teaching physics for over 20 years and have witnessed several curriculum reforms. I believe that physics teachers should put effort into researching experiments and teaching aids, just like how I have developed several sets of demonstration experiment tools and even won awards from the city. It is not enough to simply explain scientific concepts rigidly according to textbooks because true understanding of science comes through experimentation. Therefore, besides being a teacher, I can also be considered a researcher. Regardless of educational system reforms, science education must always adhere to scientific principles, which is something I have upheld for so many years. Of course, this only represents my personal viewpoint and cannot expect all teachers to act in the same way. The reason why I am interested in innovative experimental tools mainly stems from two factors: firstly, our school had limited resources in earlier years and we needed to find ways to conduct experiments ourselves; secondly, now that conditions have improved and schools purchase complete sets of laboratory equipment, few people are willing to spend time and effort on their own research. (Z6)*

This old teacher's viewpoint has several noteworthy characteristics: firstly, he believes that science teachers should not be limited to knowledge from textbooks, but should focus on experiments. Secondly, it is crucial to grasp the core of educational reform by following the development patterns of various disciplines such as physics, chemistry, and biology, with emphasis placed on experimental components in each curriculum revision. Lastly, there is a decreasing trend in the number of science teachers engaged in scientific research due to both subjective and objective factors. Regarding this last point, Tianjin's teachers have put forward their own perspectives on time allocation for teachers.

> *Actually, what I want to say is that it's not that I don't want to do research outside of class. The school also encourages us to do so. However, besides teaching, the teachers have to participate in many activities such as competitions at the district and city levels, and they also have families and children to take care of. My energy is really limited! As long as I handle matters related to my professional title well, it's enough. In other aspects, I will follow the school's arrangements because opportunities to exercise subjective initiative are few after all. (T2)*

From the perspective of this teacher, apart from their role in the classroom, teachers also have to take on responsibilities in school activities and societal/family obligations. How to manage the relationship between teaching, research, and personal life has become a core aspect for teachers in the new era. In this regard, a chemistry teacher with a master's degree and three years of teaching experience tends to view reform as both a challenge and an opportunity for transforming their identity as a teacher.

> *During my postgraduate studies, I began contemplating the transformation of the teaching profession and delved into designing chemistry lessons based on developing core competencies. This approach particularly emphasizes the urgent need to cultivate students' well-rounded development, innovative thinking, collaborative spirit, and critical thinking in the context of the new era. Therefore, I believe that educational reforms have provided me with numerous opportunities for academic research. I have also attended lectures and forums organized by Tianjin Normal University as well as online seminars hosted by Beijing Normal University, which have greatly inspired me. However, my teaching experience is still limited at present; therefore, I need to engage in further reflection and learning. (T4)*

In the eyes of these teachers, curriculum reform is about guiding students to shift from passive knowledge acquisition to active exploration and practical application, enabling them to apply what they have learned in real-life situations. Such a transformation requires teachers to constantly update their educational beliefs and methodologies, actively engage in professional development training. At the same time, these teachers are aware that they may encounter various difficulties and challenges during the process of promoting curriculum reform. For example, how to balance knowledge transmission with cultivating core competencies, or how to evaluate students' performance in terms of core competencies. However, instead of shrinking back or complaining about these difficulties, they view them as opportunities for growth and progress.

Overall, this group of teachers holds a positive attitude towards the transformation of their teacher identity and is willing to actively embrace and adapt to the requirements for educational goals and methods in the new era. Through continuous efforts and practice, they have achieved certain results in promoting the cultivation of core competencies and are willing to share their experiences and gains gained from practice.

However, for some teachers, they believe that the mechanism for evaluating teachers has

major issues. They point out that new curriculum designs and academic levels do not necessarily equate to a teacher's teaching ability and student performance. In the actual teaching process, an excellent teacher not only needs solid academic knowledge and extensive professional background but also requires teaching experience, the ability to inspire student interest, and comprehensive student management skills.

> *The so-called curriculum design and teaching methods, to be honest, I don't really understand them. Concepts or terms like group teaching, cooperative learning, flipped classroom, differentiated instruction are just empty words for us frontline teachers. In my opinion, a teacher's performance in class does not necessarily correlate with the students' academic achievements. There are some teachers who have won top awards at the city or even national level but their students perform poorly. For example, my English teacher in high school was one of the few nationally recognized master teachers in the country and had received numerous awards for his teaching methods that even had an impact on international secondary education. However, our class performed quite poorly under his guidance. But when we switched to another experienced teacher in our senior year who may not have been as famous but possessed strong abilities and taught diligently without seeking attention, our class achieved excellent results in the final exams. Therefore, being a renowned teacher does not guarantee effective student instruction. To me, these teaching methods and designs seem nothing more than promotional slogans or mere formalities. (C1)*

Represented by the response of the teachers, several viewpoints are expressed: firstly, they believe that when evaluating teachers, more emphasis should be placed on their actual teaching effectiveness and the extent to which they meet individual students' differentiated needs. Each teacher faces student groups with different grades, levels, and characteristics, so the teaching methods and approaches they adopt also vary. The evaluation mechanism should take these factors into consideration and assign corresponding weights. Secondly, evaluations should also focus on whether teachers excel in classroom management. In addition to imparting knowledge, teachers also bear responsibilities such as guidance, counselling, and maintaining class order. An outstanding teacher can effectively organize class activities, establish good interpersonal relationships, and enhance overall classroom atmosphere through appropriate motivational means. Furthermore, other participants' opinions can be introduced into the evaluation mechanism for diversified assessment.

In summary, from the responses of teachers in this section, it can be seen that the diversification of teacher roles has become an important aspect of professional development. How to help teachers find a balance among their multiple identities as knowledge disseminators, educational researchers, scientific investigators, and student managers can be crucial in large-scale curriculum reform practices. It is also a matter of genuine concern for the teaching community.

Theme three: Teachers' professional development

Due to the introduction of the ‘course selection and class scheduling’ system, not only has it had an impact on students' learning methods and course choices, but it has also brought about a series of changes in teacher arrangements, career development, and planning. Firstly, there has been a sudden decline in the number of students choosing traditional key subjects such as physics, which directly leads to many Physics teachers being forced to change positions or switch professions. They need to readjust to new teaching content and methods while facing related training needs. For example, physics teachers in Zhejiang province have expressed that there is a significant gap in the subject matter of physics.

> *Physics has transformed from a once prominent discipline to one that is now being overlooked, with many students opting not to choose it. It's disheartening for teachers to see such an important subject go unselected. Additionally, due to variations in the scoring system for elective subjects in the annual college entrance examination, there has been a gradual decline in the number of students choosing physics as their elective. This trend has led some physics teachers to consider switching careers, such as transitioning into teaching information technology.*

For T2, a teacher in Tianjin, the decision to switch from physics to technology was a reluctant move. This choice not only made him contemplate his career development but also posed greater challenges for education in remote and rural areas.。

> *I started transitioning to a technical role this year, which is not directly related to educational reform. It can be considered as being part of the school's teacher reserve program. There are also other teachers who have been temporarily transferred to different schools. After the reforms, each school has its own unique situation. Personally, I'm doing quite well. Previously, I also taught information technology courses alongside my regular teaching duties. I've heard that some schools require students to choose between physics and history in order to ensure a higher enrolment rate for physics classes; otherwise, there would*

be an excess of physics teachers facing unemployment. (T2)

Secondly, the 'course selection and class rotation' system may lead to an increase in the enrolment rate of certain non-core subjects, causing some teachers to feel confused about their career development. Teachers who excel in other subjects but are not popular may experience increased pressure due to a lack of corresponding resources and support. For example, teachers in Zhejiang province have expressed concerns about the current 'biochemistry fever'.。

Our feeling as frontline teachers is that there has been a significant decline in the quality of students' learning. The change in this mode and format of classes has made students less focused on their overall learning process during their first year of high school, which is a stage where they have the freedom to choose their subjects. However, the knowledge taught in the first year is relatively basic and can easily lead to 'miss election'. For example, biology appears to be an easy and rewarding subject within the science discipline during the first year, so some students who perform well in several exams may lean towards choosing biology for college entrance exams. However, when they reach their second year of high school, they realize that biology becomes much more difficult and consider switching to other subjects. (Z11)

In addition, after the implementation of the 'course selection and class selection' system, some teachers may need to undertake more teaching tasks at different grades, levels and even across disciplines. This undoubtedly adds to their workload and challenges, and requires them to have a broader knowledge base and the ability to respond flexibly to various situations. For example, a biology teacher from Zhejiang said that excessive autonomy is not necessarily conducive to the development of students, but also has an impact on the development of their own education work.

The teaching format of flexible scheduling seems to provide students with a greater space to choose their own learning content and development direction. However, in reality, there are connections between subjects. The traditional separation of arts and sciences is still considered necessary by many frontline teachers. For example, the contents of physics, chemistry, and biology are interrelated. When discussing topics such as proteins or genes, much of the content requires knowledge support from chemistry. Now we encounter a problem where students who haven't chosen chemistry find it difficult to understand molecular structures when I teach that topic. Unlike before when all science subjects were studied together, there was a mutual reinforcement effect. Therefore, after implementing elective

courses with flexible scheduling, students face some challenges in dealing with the interrelationships between different subjects' contents. Additionally, another issue arises when some students in the same class choose chemistry while others don't; this was rarely encountered in previous teaching work. (Z9)

This change has also brought new opportunities for the development of subject teaching. After the implementation of reforms, teachers need to constantly update their knowledge and skills to adapt to the new educational requirements. It also means that they need to engage in interdisciplinary teaching research activities with teachers from other subjects and actively explore innovative teaching methods and strategies. For example, a chemistry teacher from a key middle school in Zhejiang expressed the changes in his teaching.

Since our school does not intervene in students' choices and allows them to make their own decisions, some students may end up choosing biology without selecting chemistry. We all know that biology and chemistry are closely intertwined, with many biological concepts relying on a foundation of chemical knowledge. As a result, many biology teachers come to me for chemistry teaching materials or discuss interdisciplinary instructional designs. I believe this is also a promising direction for development, and I have suggested to the school that we should encourage young teachers to engage in cross-disciplinary research activities. This way, we can explore how to better help students adapt to the new curriculum under different choice scenarios. (Z10)

Of course, there is also certain pressure in terms of resource allocation. As the attention towards certain emerging disciplines increases and leads to a rise in demand, it becomes necessary to invest more resources such as manpower and finances to meet this demand. This requires management to consider timely balance and adjustments among different disciplines when allocating resources. The teacher who is also responsible for administrative work at the school believes that factors at the institutional level are important constraints on reform.

Our school has always been focused on science subjects, with teaching resources being biased towards the sciences. For example, before the separation of arts and sciences, the number of students choosing science was consistently four to five times higher than those choosing arts. However, now the ratio is not so disparate anymore. We are already feeling stretched thin, and other schools also have their own difficulties. Therefore, I believe that schools need to have their own strategies instead of blindly letting students choose for themselves; there should be a certain degree of intervention and guidance. Additionally,

teachers are also concerned about the impact on future title evaluations and there is some instability in morale among them. Hence, our management team cannot be too radical in reform but must proceed gradually until the situation stabilizes. (Z7)

In summary, the impact of curriculum reform on teachers' professional development is reflected at both individual and school levels. At the individual level, the influence is manifested in the challenges and opportunities for one's own career prospects due to the redistribution of teaching resources resulting from elective courses and flexible class schedules. On school level, the impact focuses on the degree and inclination of radical changes during reform, which to some extent depends on whether schools have sufficient teaching resources to provide adequate support for teachers while also being able to summarize and address issues arising from reform practices and teacher feedback.

Only two teachers (one from Chongqing and one from Zhejiang) in all participants have not received new curriculum related training course. Educational policy, educational theory, pedagogical knowledge course, and curriculum design training course are mostly mentioned by teachers to support their work. However, most teachers are not satisfied with these trainings. Hence, here with a representative example in which this teacher indicates that the fact that he thinks trainings are useless.

About content of training, there are policy theories and practice, but the most significant issue is that the stakeholders and policy makers are unfamiliar with teachers who are teaching. For example, researchers like you who are doing research about pedagogy or curriculum have little connection with us. They just have speech with some theories which cannot directly use in class teaching and not meaningful for students. (T1)

Them four: Teachers' feedback on the impact of curriculum reform on students

Teachers are highly concerned about the impact on students during the implementation of curriculum reform. They are well aware of their responsibility to explain the new curriculum and teaching arrangements to students and their parents, so they pay extra attention to policy changes regarding student reforms and other schools' experiences in reform.。

Both students and parents will inquire about the progress of our reforms right away, and we certainly cannot give uncertain answers. However, it is true that there may be adjustments in the specific implementation of policies during the initial stages of reform. We can only offer suggestions to the best of our abilities. The school also organizes parent meetings specifically to convey the spirit of reform policies and share experiences from other schools through participating in educational research activities organized by the city. (Z5)

Most teachers think the curriculum reform may put more academic pressure on students. With the adjustment of new course content and requirements, students need more time and energy to adapt and master the new knowledge. This undoubtedly poses a challenge for them, especially when it comes to exams, assignments and other assessments. The interviewed teachers in Zhejiang have a complete experience from the beginning of the curriculum reform to the graduation of this batch of students, so they can give feedback on the experience of the first batch of reforms from a macro perspective。

From the perspective of our school's first batch of students, the academic pressure on students has increased significantly. There are fewer self-study courses and fewer extracurricular activities. At the same time, students feel that they have limited time and heavy workload, to the point where they can't even finish their assignments. Some students may also experience more anxiety compared to previous years' students. I believe that this situation will inevitably affect their performance in college entrance examinations to some extent. However, the increase in available subject combinations also meets the needs of students, allowing them to choose a combination that suits them better and improve their overall scores. (Z12)

Some teachers are concerned that students lack sufficient autonomy in choosing their courses. In the traditional education model, students typically only need to choose between humanities and sciences, without having to expend much energy contemplating the relationship between subject selection and future development. As a result, some of the pressure is shifted onto teachers and parents.。

Starting from the first year of high school, students should have a sense of elective exams and career planning. However, young students may not be able to effectively plan their careers. The selection of elective subjects is often driven by opportunistic factors, rather than personal interests or professional considerations. The opinions of parents and teachers also greatly influence students' choices.

I have advised many students not to easily choose science subjects. The transition between the first and second years of high school is significant, and it can be troublesome if they realize in the second year that they are struggling with what they have chosen. I also communicate with parents to see if it's a decision made within the family.

Of course, I respect children's choices as well. But you know how it goes – a child's interest is closely related to their academic performance. For example, if they perform well in physics today, they will develop more love for the subject. However, if their next exam doesn't go well, their interest might fade away again – this is quite common. (Z1)

Another aspect is the increasing pressure of exams. Although the current education system has begun to advocate for comprehensive quality evaluation and gradually reduce the practice of measuring ability solely based on exam scores, high school entrance exam results still play a decisive role in enrolment. The following teacher has his own opinions and suggestions regarding the current examination evaluation format.。

Since now it's not possible to take two exams for one subject, for example, we could have taken the chemistry exam in the second half of the first year. This leads to a long gap between the two elective exams. Originally, one exam would have sufficed, but now we have to go through exams from the first year all the way until the third year. Many parents have communicated with me after graduation and expressed how tough it is. It used to be that we would work hard in our final year of high school (grade 12), but now it feels like we are constantly taking exams from grade 10 onwards until grade 12. It's truly exhausting. Our teachers also face great challenges and hardships due to this situation. Therefore, I hope there can be some optimization in the future to shorten the interval between these two exams. (Z11)

From the interviewed teachers in Zhejiang, curriculum reform may increase students' learning pressure and teachers' teaching pressure. Of course, this is also a problem that will inevitably be encountered in the early stages of reform. However, from the feedback of teachers in Chongqing, we can see the issues arising from implementing reforms across different regions.

Therefore, it is my overall view on the big issue of the new college entrance examination reform. At present, it is the college entrance examination reform. Or as far as I know, laugh, because Shanghai and Zhejiang were the first to change, then you have a problem there, have already had a problem, or have proved some of the failure of the college entrance examination reform. So now, in the second batch of pilots, Tianjin ah, Beijing in the process of this second batch of pilots, has gradually overcome some of the shortcomings of the reform of the college

entrance examination in Zhejiang and Shanghai, but I now look. The evaluation of our first-line teachers on the reform of the college entrance examination is also negative or negative. (C1)

The teachers in Tianjin also expressed that they have learned from the experience of Zhejiang and made some adjustments at the school level.

We also organized a study exchange in Zhejiang to learn from their experience. They suggested that we should not fully open up student choices, especially for schools in suburban areas and non-prestigious schools. Instead, we should offer students some 'package options' based on our own school's characteristics, which would be more manageable. Our school has also learned from the lessons of others and currently the reform seems to be relatively stable, without as much opposition as in Zhejiang. (T3)

Therefore, teachers believe that the influence on students is mainly due to different regional and school development, and a standardized reform policy should not be applied. This would result in educational inequality. To avoid this phenomenon, it is necessary to coordinate teaching resources in each region, determine course selection based on the characteristics of each school's education and curriculum, actively understand students' intentions through effective communication with students and parents, and achieve genuine student autonomy in choosing their own developmental path.

The role of teachers and students in classroom teaching has always been a topic of great concern. In response to this issue, I interviewed some teachers and found that they generally agree with the core idea of 'teacher-led, student-centred'. However, there are some differences among different teachers on how to develop this issue in the future.

Some teachers believe that in the future classroom, there were significant changes in the roles of teachers and students. They firmly believe that the traditional division between 'knowledge providers' and 'knowledge receivers' remains valid, and they thought this relationship was affected by reforms. According to their perspective, teachers should continue to play an important role as guides, mentors, and inspirers of student thinking, while students need to actively participate and acquire knowledge from their teachers. For example, during a previous discussion on teacher identity, Teacher C1 believed that teachers must maintain a dominant position in teaching. Additionally, he compared the situation of students before and after curriculum reform and

concluded that it has little impact on high-performing students but significantly influences the learning attitudes of average-performing students.

> *Comparing the current second-year students with the current third-year students, the third-year is still following the old policy while the second-year is under a new policy. In terms of mastery of the same knowledge, third-year students surpass second-year students by far. It's not just about studying for an extra year and achieving better results; when it comes to subjects like biology, third-year students excel much more than their second-year counterparts. Therefore, what I want to express is that there has been a change in these students' attitudes towards learning. For good students, it doesn't affect them much as they continue to study diligently. However, for average or slightly below-average students, their learning attitudes are negatively impacted. So if I were to pay special attention to individual students or because of certain individuals slowing down the teaching progress, it would be unfair to other students. (C1)*

However, there are also other teachers who hold different views. They believe that with the progress of time and changes in societal needs, there would be more interactive, collaborative, and even autonomous learning modes in future classrooms. In such cases, teachers may focus more on cultivating students' abilities in independent thinking, problem-solving, and teamwork skills among others. Gradually, they may transform into facilitators, guides or collaborators. For example, Z2 and Z8 from Zhejiang province both believe that equality between teachers and students can be a major trend in development. Therefore, it is necessary to research relevant curriculum and instructional designs to adapt to future developments. The following teachers express similar viewpoints based on the characteristics of their respective schools.

> *Our school has always placed great emphasis on student-centred new teaching and learning models, as well as encouraging teachers to explore increasing classroom interactivity and fostering students' ability for independent learning. I believe this aligns perfectly with the current promotion of developing core competencies. In the future classrooms, students' roles will definitely go beyond just acquiring knowledge and answering questions; they will begin to learn how to think, discuss, and inquire. These abilities are essential in subjects like physics and chemistry. Our school also organizes visits to domestic and foreign universities for students to experience university life firsthand, laying a solid foundation for their future development. (Z10)*

Some teachers also believed that the reform bring about changes in the roles of both teachers

and students. Encouraging autonomy in learning and critical thinking is becoming a trend, especially for high school students' participation in classroom teaching practices. However, this also increased the pressure on students, as a considerable number of them may struggle to adapt to such changes. The following teacher presents their own views on the issue of teacher-student roles based on their practical experience.

> *This is not a new problem. It has been raised for many years. I think this should be a gradual process, as thinking and abilities are not something that can be forced. For example, I have organized group discussions before, but many students just chat instead of discussing because they haven't had this atmosphere since primary school or junior high. If you suddenly change the approach, only those who were previously more active will speak up while those who are usually less proactive won't know what to say; they may fear saying something wrong or simply lack ideas. Therefore, I believe that this classroom transformation should start from an early age because by the time they reach high school, it won't work if we don't allow them to discuss. (T1)*

In result, under the current context of reform, it has become a common pursuit to promote the development of the education system towards being more open, flexible, and inspiring. This corresponds to changes in teachers' identities and the development of their professional skills. Similarly, students may seek more voice and new roles in teaching practice.

5.4.3 ***Discussion***

This section primarily focuses on the experiences and insights of teachers in undergoing curriculum reform. As responds of research questions 2 of this study: ‘What are science teachers’ experience and reflection on the new curriculum implementation?’ and ‘What are the factors that affect the implementation of curriculum reform?’, science teachers’ interviews have been coded in themes and categorised in the terms of personal, internal and external contexts to show the factors influencing the implementation of curriculum reform. In addition to personal factors of teachers, factors both within and outside the school are also considered in this analysis, aiming to gain a comprehensive understanding of the challenges faced by teachers in curriculum reform and their potential roles. The following discusses some findings from the analysis of teacher interview data.

The Factors Influencing Teachers' Attitudes towards Curriculum Reform

Firstly, from the analysis of teacher interviews, it can be observed that teachers' attitudes

towards curriculum reform can be categorized into four types based on their understanding and acceptance of the reform as well as their responses to it. 1. Teachers who comprehend the meaning of curriculum reform and actively adapt to it; 2. Teachers who understand the meaning of curriculum reform but lack knowledge or guidance on how to implement it specifically; 3. Teachers who fail to understand or agree with the meaning of curriculum reform and continue teaching according to their original plans; 4. Teachers who fail to understand or agree with the meaning of curriculum reform but passively participate in it due to pressure.

In organizing the experiences and feedback from teachers regarding the new curriculum, I believe that several factors primarily determine whether teachers can understand and embrace the implications of curriculum reform. Firstly, it lies in the teacher's curriculum consciousness, which refers to their understanding of curriculum and curriculum reform. The core of a teacher's curriculum consciousness is their perspective on curriculum. This perspective is formed based on their perception of the curriculum during professional practice and encompasses their overall views and fundamental beliefs about it. It includes an understanding and judgment of the content, value, function of the curriculum, as well as their own relationship with it.

Teachers naturally focus on practical teaching processes and evaluation procedures. For example, many interviewed teachers perceive the core of curricular reform as being related to 'course selection flexibilities' or 'college entrance examinations.' In traditional school education, all professional practices by teachers revolve around delivering content directly from textbooks to students without considering whether these contents are suitable for students' actual needs. This understanding makes some teachers unwilling or unable to truly comprehend intended curriculum and thus tend to resistance and negative responses during implementation of new curricula.

However, at the same time, I have also observed that some teachers are able to see the greater need for teacher awareness and curriculum concepts in the new era's curriculum changes. In a teacher's mindset, classroom teaching environments cannot be completely ‘accurately predicted or designed’ beforehand but are constantly changing. Curriculum implementation can only achieve good results by making corresponding adjustments based on specific classroom teaching situations and students' actual conditions, thus achieving effective teaching as a pursuit goal in a teacher's professional practice.

Secondly, in terms of the impact on teachers, the implementation of the subject selection and flexible class system can promote self-renewal and reflection in the educational process. It also encourages interdisciplinary communication and collaboration among teachers, aiming to break down disciplinary boundaries and explore new possibilities for curriculum and instructional design. This indicates that the new curriculum is influencing teachers' teaching behaviours. In order to adapt to the 'integration' of the new curriculum as well as the need for curriculum innovation, teachers must continuously acquire information, process it, and output it. Therefore, cooperative 'professional complementarity and collaboration' among teachers becomes inevitable. Currently, teacher cooperation has shifted from formal organizational forms such as subject groups or grade-level teams in the past to an autonomous and conscious professional development driven by internal needs for their career development. However, at present, these attempts are limited to individual teachers; there is no systematic environment within schools that promotes such changes and growth.'

Furthermore, from the perspective of schools, the emphasis on 'the rate of admission to prestigious undergraduate programs' is a commonly observed phenomenon in the field of Chinese high school education. This directly determines the status and level of resource acquisition for schools within their respective regions. As a result, schools and principals may appear hesitant when implementing curriculum reforms and ensuring high rates of admission to prestigious undergraduate programs. This hesitation is directly reflected in difficulties encountered in resource management and allocation. Schools are unable to effectively resolve conflicts between teacher and student needs and resource distribution, leading to significant dissatisfaction among both teachers and students. These negative emotions can also hinder the successful implementation of new systems. Additionally, under this new model, teachers need to design differentiated learning choices and arrangements for different students to facilitate personalized development. Consequently, work systems such as lesson preparation and educational research activities require extensive adjustments. The mobility of students also weakens class cohesion and diminishes their sense of belonging, making it more challenging to manage attendance, discipline, homework assignments, and academic support for students.

Many schools, to alleviate this pressure, can only choose to adjust the reform. For example,

a school in Tianjin interviewed teachers and adopted a ‘package’ elective course model. Although this compromise reform has reduced the burden on teachers to some extent, it deviates from the requirement of focusing on students' autonomous choice and development in the intended curriculum, ultimately leading to formalized reform. The compromising attitude of schools would greatly influence teachers' attitudes towards curriculum reform. They may consider the reform as just going through the motions and continue teaching based on traditional textbook content and exam preparation. Most schools focus mainly on coping with college entrance examinations in terms of curriculum development and arrangement, neglecting the practical significance of elective courses and flexible scheduling. As a result, there is an obvious formalization phenomenon in changing teaching models, which is still at an exploratory stage for personalized student development and difficult to fully utilize the practical function of subject selectin and flexible scheduling.

Apart from factors at the school and teacher levels, curriculum practice is also influenced by external factors that attract attention. Currently, society and parents generally obtain information about the school through two types of channels to provide feedback. One type is the normal channel, which includes ‘open days’ every semester and parent committees at both the school and class levels. The other type of channel involves parents obtaining ‘unofficial’ information through their observations and experiences, and based on their private analysis, one or several individuals collectively raise inquiries or claims to teachers themselves, the school's management department, or even directly to the principal. Regardless of which type of channel is used, the transmitted information serves as feedback from society and parents regarding current educational practices, quality, and effectiveness of the school and teachers. Whether positive or critical in nature, these feedback imply expectations and demands towards the school and teachers. Both schools and teachers generally provide formal or informal responses to received information from parents and society; especially for criticisms that require improvement or resolution because sometimes parents may complaint to higher authorities if not addressed promptly.

Therefore, many teachers lack initiative and enthusiasm in the reform. They often feel that they have no say in the design of reforms and are unable to participate in decision-making processes, resulting in a lack of motivation to drive the reforms. In such situations, teachers can

only passively accept instructions and requirements from superiors, making it difficult for them to unleash their creativity and professional knowledge. At the same time, when facing reforms, teachers also worry about the impact on their work efficiency. The high time cost required for adapting and implementing new policies and methods, as well as the need to relearn relevant knowledge and skills may cause confusion and pressure for teachers in the short term. If work efficiency decreases or problems cannot be resolved promptly, it is easy to trigger resistance emotions.

Apart from concerns about work efficiency, relatively large-scale reforms can also bring anxiety to teachers in terms of their career development. Especially when new policies involve evaluation systems and promotion mechanisms, teachers may feel an increase in uncertainty. They worry about whether they meet the new standards, whether they have enough competitiveness, and how to adapt to changes, which leads to confusion in their career planning. In short, there are various problems and concerns during the reform process, and not all teachers can actively engage in it. To better promote the reform process in the field of education, it is necessary to pay attention to and give teachers more voice in participation, provide support and training opportunities for them, as well as implement specific measures that are feasible with clear goals.

The transformation of Teacher's role and Identity Recognition

As teachers involved in curriculum reform, they face new issues of identity and the new roles proposed by the curriculum reform. The new curriculum puts forward requirements beyond the task of knowledge transmission for teachers. For traditional teachers, classroom teaching is centred around subject knowledge content, and their identity is deeply rooted in this core aspect. For example, many interviewed teachers believe that the main or only task that teachers need to focus on is imparting knowledge or reflecting it in students' grades. This mindset can lead to a decrease in attention towards cultivating students' emotional attitudes and values. One of the emphasized concepts in this new curriculum reform is to change the dominant position of regarding teachers as mere ‘tools’ for implementing curricula in China's education field. Overcoming the phenomenon of opposition between curricula and teachers in the education field, returning corresponding curriculum rights to teachers who are subjects of curricula. Ultimately, achieving a transformation from passive ‘faithful implementers’ of curricula to active regulators or creators

within professional practice for teachers.

In the new curriculum, the transformation of teachers' roles first occurs in their identity as knowledge providers. Based on the fundamental concept of 'cultivating virtue and nurturing talents' proposed by the new curriculum and developing students' core competencies, the teaching process is not only about students acquiring knowledge but also about their holistic development. This developmental process should be continuously adjusted according to students' individual circumstances and characteristics, transitioning from a previous emphasis on uniform teaching to truly tailored instruction.

However, there are different opinions among teachers regarding how to prioritize student-centeredness in teaching. The main disagreements lie in student evaluation and classroom management issues: some teachers believe that evaluating students and determining their future development through college entrance examinations should be based on their exam scores or comprehensive ability assessment. Only through reforming college entrance examinations can curriculum and teaching undergo meaningful changes. Otherwise, all changes would ultimately become superficial without truly penetrating school teaching practices.

Furthermore, many regions in China currently lack genuine conditions for small-class teaching. If too much consideration is given to students' needs and autonomous development, it may consume teachers' instructional time and increase classroom management costs, thereby affecting both instructional progress and quality. As a result, it becomes difficult to truly achieve the goals of implementing curriculum reforms.

Secondly, the role of a researcher within the teacher's identity is also a new requirement proposed in the new curriculum. The researcher's identity manifests in two ways among teachers: firstly, viewing oneself as a scientific researcher. Compared to humanities subjects, scientific disciplines involve more experiments and practical work. Some teachers utilize their work and spare time to conduct research on teaching aids and experiments. This kind of research not only helps teachers integrate knowledge with practice during the teaching process but also assists in addressing the issue of inadequate teaching equipment and experimental instruments in some rural schools.

On another aspect, it involves educational research practices by teachers themselves. They

transition from being mere implementers of school-based curricula to becoming creators and developers of distinctive curriculum systems. They shoulder the responsibility of creatively designing learning processes that facilitate collaboration between teachers and students while fostering students' scientific inquiry skills.'

Finally, in addition to teaching tasks, the role of teachers has shifted from managing classroom discipline to cultivating students' learning habits, scientific competencies, and scientific spirit. This also brings about dynamic changes in the roles and positions of teachers and students in the new curriculum. For Chinese teachers, there has always been a contradiction between 'respecting teachers and valuing education' and 'equality between teachers and students'. The current new curriculum emphasizes equality between teachers and students, with teachers as leaders within this equality; it emphasizes that teachers should become helpers, guides, and facilitators for students to actively construct knowledge, returning the initiative of learning to its actual subject - the student. Under this new perspective on teacher-student relationships, educational beliefs, and views on learning, a professional outlook centred around meeting the growth and development needs of students has increasingly been accepted by frontline educators in general basic education. And 'teaching according to individual differences,' as an ancient teaching principle from Confucius, is already well-known among teachers. However, in their actual teaching activities, the application of this principle has indeed been unsatisfactory for quite some time. The reason generally believed is due to how 'teaching according to individual differences' is combined with actual instruction. In my opinion, the first problem that needs addressing when applying this principle lies in transforming and updating both the teacher's educational beliefs and the student's perspectives.

5.5 Summary

This chapter analyses interviews with principals and teachers to explore the feedback and perspectives of principals and teachers during the stage of curriculum reform practice. As a response to research question 2a, the expressions of three principals reflect their different attitudes towards curriculum reform and their distinct feedback as leaders in implementing curriculum reform. Principals' attitudes towards reform can be categorized into four types. (Reiterating

original text) At the same time, there are two sets of organizational structures within principal's curriculum leadership: management leadership and curriculum leadership. Both sets play their respective roles, but in curriculum reform, it is necessary for principals to exert their influence at the school level by attempting to move away from strategies focused on management and control. The model of curriculum leadership, as a future trend, gradually establishes its position within schools along with the implementation process of curriculum reform, playing a role in various aspects such as curriculum implementation, evaluation, and resource coordination.

As a response to research questions 2b and 2c, teacher interviews reflect the perspective of teachers on science curriculum reform, including a series of influencing factors such as personal, internal, and external influences. From the analysis results, teachers have complex attitudes towards the current state of curriculum reform and concerns about their own career prospects. At the same time, influenced by multiple factors from students and schools, teachers also contemplate their roles in education and educational reform. These concerns and contemplations have a wide-ranging impact on the practice of reform. Although this influence may initially have negative effects on reform practices in the short term, in the long run, it is crucial for teachers to deeply engage in curriculum reform practices to achieve intended curriculum outcomes. However, different schools vary in their ability to support teachers due to limitations imposed by teaching resources, priorities, and student sources. Additionally, social pressures from parents and support from educational researchers also influence teacher implementation of reforms. Therefore, while it is hopeful that teachers can exert significant power in curriculum reform efforts, it is also likely that comprehensive implementation may be challenging due to internal and external factors at play.

As a response to the research question, teacher interviews serve as an important avenue for understanding the perspective of teachers on science curriculum reform. Through analysing the results of these interviews, it can be observed that the complex attitudes exhibited by teachers when facing curriculum reform and their concerns regarding their own professional development prospects. Meanwhile, teachers also mentioned in the interviews much feedback from students and parents regarding curriculum reform. Therefore, in the next chapter, I analysed students' scientific attitude questionnaires and conduct student interviews to understand and discuss the role and involvement of students in curriculum reform.

Chapter 6 Analysis of the Attained Curriculum

6.1 Overview

What is the impact of the new curriculum on high school students' science-related attitudes and how do students experience the curriculum reform?

Sub-question 3a: What is the impact of the new curriculum on high school students' science-related attitudes at the beginning of the curriculum reform?

Sub-question 3b: How do high school students experience the new curriculum?

6.2 Analysis of Student Questionnaire Data

6.2.1 *General Data of Participants of this Study*

In this section, a survey was conducted on the attitudes of middle school students towards science. A total of 215 questionnaires were collected, with 212 valid questionnaires and 3 invalid ones (2 individuals selected all options as 5 and 1 individual selected all questions). The survey targeted students from the first and second grades of high schools in Tianjin. As shown in the table, female students accounted for 52.1% while male students accounted for 47.9% among those who participated in the questionnaire survey. There were more participants from the second grade, accounting for 71.2% of the total number of respondents, while first-grade high school students accounted for 28.8%. The questionnaire was distributed during the mid to late period of the autumn semester, so first-grade high school students were new to high school and had not yet determined their elective courses, while second-grade students had already experienced one year of flexible teaching and had chosen subjects that would

determine their college entrance examination scores.

Table 6.1

Valid participating students in this study

Gender Grade	Male	Female	Total
Grade one	73	78	151
Grade two	28	33	61
Total	101	111	212

When students choose subjects, they consider to be science-related, chemistry has the highest percentage of selection, with 88.8% of students including it in the category of science courses. Physics follows (86%), followed by experimental practice (82.2%), biology (78.5%), and geography (42.5%).

Table 6.2

Subject chosen for science

Subjects Chosen	Num	Percentage (%)
Physics, Chemistry, Biology, Experiment	67	31.6
Physics, Chemistry, Biology, Geography, Experiment	46	21.7
Physics, Chemistry, Experiment	15	7.1
Physics, Chemistry, Biology	14	6.6
All	9	4.2
History, Geography, Politics	6	2.8
Only Experiment	5	2.4
Physics, Chemistry, Biology, Geography, History, Experiment	5	2.4
Physics, Chemistry, Biology, Geography	4	1.9
Others	4	1.9

The science class types, including traditional science with experiments (31.6%) and traditional science with geography and experiments (21.7%), account for 53.3% of all students. The top 10 class types with the highest percentages are shown in the Table 6.2.

In the field of school education in China, it is common for science classes to encompass subjects like physics, chemistry, and biology. However, this survey reveals that 7% of students include traditional humanities courses in their definition of science classes, showcasing their innovative thinking and courage to express themselves. When

selecting a type of science class, students are not constrained by preconceived notions but rather define them based on personal judgment.

6.2.2 *Reliability Analysis of the Attitude Measures*

As discussed in Methodology chapter, This study made relevant modifications to the questionnaire developed by Kind (2007) based on the actual situation of the measurement object. A good questionnaire must have high reliability. This section examined the internal reliability of these measures. One of the most frequently employed approaches to assess reliability involves examining the interrelationships among individual items within the assessment (Finch & French, 2019).

'Cronbach's α is probably the most widely used and reported estimate of reliability throughout the social sciences and is easily obtained using standard software packages such as SAS or SPSS, which does not imply it is always ideal, but rather the most readily available at this point in time' (Finch & French, 2019, p. 53). Table 6.3 presents the Cronbach α values for each measure. Prior to carrying out the reliability calculations, all negatively worded items were reverse coded.

Table 6.3

Cronbach's α reliability values for each attitude measure

	Cronbach's α	Items
Whole attitude measure	0.920	37
Learning Science in School	0.895	6
Self-concept in Science	0.836	7
Practical work in Science	0.860	7
Science outside of school	0.892	6
Future participation	0.891	5
Importance of Science	0.823	6

According to the range of alpha coefficient values and the effect of reliability: 0.80-0.90 is very good, 0.70-0.80 is quite good; 0.65-0.70 is the minimum acceptable value; it's best not to have a range of 0.60-0.65.

Therefore, based on the table, it can be seen that both the questionnaire and its sub-items have relatively high alpha values, indicating a good level of internal consistency

in the data.

The results obtained are similar to those from the pilot study.

6.2.3 *Validity Analysis of the Attitude Measures*

Construct validity refers to the extent to which test scores can explain the structure or characteristics of the underlying theory and can also be understood as the degree to which a test actually measures the intended structure and features. This study aims to understand the construct validity of the questionnaire through factor analysis.

The measurement value of KMO for assessing the sampling adequacy is 0.918 (KMO values above 0.9 are considered excellent, 0.8-0.9 are good, 0.7-0.8 are fair, 0.6-0.7 are poor, and 0.5-0.6 are very poor), indicating a relatively good level (Table 6.4).

The chi-square value of Bartlett's sphericity test is 5122.570 (with degrees of freedom being 666), with a significance level of 0.000<0.01, reaching the significance threshold and rejecting the null hypothesis in favour of the alternative hypothesis that the correlation matrix is not an identity matrix; thus suggesting the presence of common factors among the correlation matrices representing the population sample and making it suitable for factor analysis.

Table 6.4

KMO and Barlett's Test

Kaiser-Meyer-Olkin	Measure of Sampling Adequacy.	.918
Bartlett's Test of Sphericity	Approx. Chi-Square	5122.570
	df	666
	Sig.	.000

Therefore, this study further analysed the construct validity using factor analysis method, extracting six eigenvalues. The contribution rate and cumulative contribution rate are shown in the Table 6.5 below.

Table 6.5

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.320	36.001	36.001	12.935	34.960	34.960

2	2.901	7.841	43.841	2.466	6.665	41.624
3	2.816	7.610	51.451	2.431	6.571	48.196
4	1.736	4.692	56.143	1.315	3.555	51.751
5	1.679	4.539	60.682	1.247	3.371	55.121
6	1.246	3.368	64.050	0.800	2.161	57.283
7	1.032	2.789	66.839			
8	0.958	2.589	69.428			
9	0.894	2.417	71.845			
10	0.799	2.160	74.005			
11	0.729	1.971	75.976			
12	0.697	1.885	77.861			
13	0.663	1.792	79.653			
14	0.622	1.682	81.334			
15	0.571	1.544	82.878			
16	0.512	1.385	84.263			
17	0.477	1.288	85.551			
18	0.456	1.232	86.783			
19	0.424	1.146	87.929			
20	0.388	1.049	88.978			
21	0.361	0.975	89.953			
22	0.351	0.949	90.903			
23	0.341	0.921	91.823			
24	0.332	0.898	92.721			
25	0.307	0.830	93.551			
26	0.285	0.771	94.322			
27	0.265	0.717	95.039			
28	0.262	0.708	95.747			
29	0.247	0.668	96.415			
30	0.227	0.614	97.029			
31	0.217	0.587	97.616			
32	0.184	0.498	98.114			
33	0.177	0.477	98.591			
34	0.166	0.448	99.039			
35	0.141	0.381	99.420			
36	0.115	0.311	99.731			
37	0.100	0.269	100.000			

Extraction Method: Principal Axis Factoring.

From Table 6.6, six factors were extracted with a cumulative contribution rate of 64.050%, which is effective. Factor rotation was performed to polarize the factor loadings, and the rotated component factor matrix is shown in the following Table 6.6.

Table 6.6

Rotated component factor matrix

	Factors					
	1	2	3	4	5	6
1. We learn interesting things in science lessons.	0.631					
2. I look forward to my science lessons.	0.785					
3. Science lessons are exciting.	0.745					
4. I would like to do more science at school.	0.717					
5. I like Science better than most other subjects at school.	0.514					
6. Science is boring.	0.567		0.417			
7. I find Science difficult.			0.686			
8. I am just not good at science.			0.796			
9. I get good marks in science.			0.455			
10. I learn Science quickly.			0.574	0.327		
11. Science is one of my best subjects.			0.521	0.471		
12. I feel helpless when doing Science.			0.526			
13. In my Science class, I understand everything.			0.438			
14. Practical work in science is exciting.	0.497	0.539				
15. I like science practical work because I can see the actual results rather than literature description.		0.622				
16. Practical work in science is good because I can work with my friends.		0.627				
17. I like practical work in science because I can do it by myself rather than teachers' demonstration.		0.643				
18. I learn science better when we do practical work.		0.667				
19. I look forward to doing science practical.	0.314	0.697				
20. Practical work in science is boring.	0.342	0.404				
21. I would like to join a science interest group.		0.346	0.321			0.509
22. I like watching science programmes on TV or online.						0.626
23. I like to visit science museums.						0.693
24. I would like to do more science activities outside school		0.310				0.545
25. I like reading science magazines and books.				0.423		0.639
26. It is exciting to learn about new things happening in science				0.426		0.582
27. I would like to study more science in the future.	0.411			0.336	0.306	0.421
28. I would like to study science at university.				0.612		0.414
29. I would like to have a job working with science.				0.676		0.360
30. I would like to become a science teacher.				0.664		

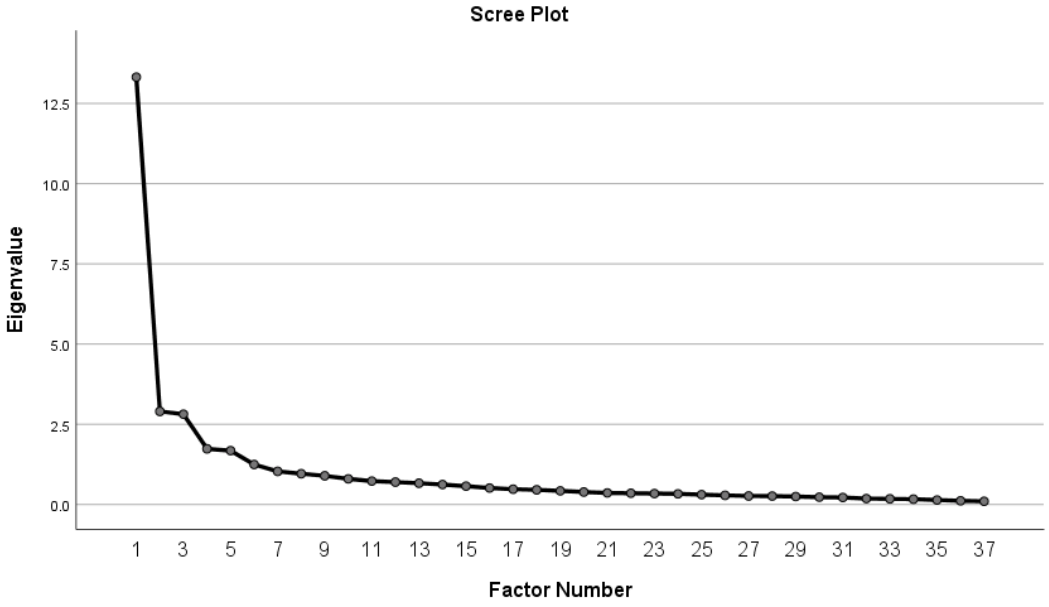
	Factors					
	1	2	3	4	5	6
31. I would like to become a scientist.				0.763		
32. Science and technology is important for society.					0.654	
33. Science and technology makes our lives easier and more comfortable.					0.758	
34. The benefits of science are greater than the harmful effects					0.478	
35. Science and technology are helping vulnerable people.					0.674	
36. There are many exciting things happening in science and technology.					0.807	
37. Scientists have exciting jobs.					0.398	

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

From the table above, it can be seen that each measurement item roughly belongs to a specific factor. The factor analysis reveals that the structure reflected in the evaluators' scores aligns with the structure of the evaluation form constructed earlier.

Figure 6.1

The scree Plot



For items 1-6, all of them correspond to Factor 1, as indicated by their factor loading coefficients exceeding 0.5, suggesting that these six items should belong to the same dimension. However, Item 6 can also be associated with Factor 2 besides Factor

1, indicating a certain correlation between Item 6 and Factor 2 which is acceptable.

For items 7-13, all of them correspond to Factor 3, as indicated by their factor loading coefficients exceeding 0.4, suggesting that these seven items should belong to the same dimension. However, Items10 and11 can also be placed under Factor4 besides Factor3, indicating a certain correlation between Items10 and11 andFactor4 which is acceptable.

The 7 items from question 14 to 20, all corresponding to factor 2 with factor loading coefficients higher than 0.4, indicate that these items should belong to the same dimension. However, questions 14, 19 and 20 can also be placed under factor 1, suggesting a certain correlation with factor 1 which is acceptable.

The 6 items from question 21 to 26, all corresponding to factor six with factor loading coefficients higher than .5, suggest that these items should belong to the same dimension. However, questions 25 and 26 can also be placed under factor four. Question 21 can also correspond to factors two and three while question 24 can correspond to factor two as well.

The 27th question corresponds to factors 1, 4, 5, and 6 with factor loading coefficients higher than 0.3. The four items from the 28th to the 31st questions all correspond to factor 4 with factor loading coefficients higher than 0.6, indicating that these four items should belong to the same dimension. However, questions 28 and 29 can also be placed under factor 6. Question number 21 can correspond to factors 2 and 3, while question number24 can correspond to factor2 as well.

The 5 items from question 32 to 37, all correspond to factor 5 with factor loading coefficients higher than 0.3, indicating that these 5 items should belong to the same dimension.

Through factor analysis, the structural validity of the questionnaire is good, and the actual model structure is basically consistent with the design structure. For the subsequent data analysis, I conduct specific analyses based on six factors separately. At the same time, I analysed three factors (Learning Science in school, Science outside of school, and Future participation in science) that have close relationships together in one section. The remaining three factors (Self-concept in science, Practical work in science,

and Importance of science) was analysed separately. In each section, analysis was conducted from three dimensions: percentage distribution of options, gender differences, and grade differences.

6.2.4 *Combined interest in science*

Overall, students are moderately positive about learning science and scientific practice, the mean of scientific attitude for all students is shown in Table 6.7. The mean score was computed from a 5-point Likert scale. 5 stands for strongly agree and 1 for strongly disagree. Items with negative wordings were reversed. Therefore, a mean score of 3 or above can be considered as positive. Participants' responses mean value in Leaning science in school are the most positive (M=3.7912), while participants' responses mean value in Future Participation are neutral (M=3.0906).

Table 6.7

Mean score for Combined interest in science measures

	N	Mean	Std. Deviation
Learning science in school	212	3.7912	0.88028
Science outside of school	212	3.5188	0.95514
Future participation	212	3.0906	0.96758
Combined interest in science	212	3.4672	0.80081

The independent samples t-test primarily focuses on determining whether there is a significant difference between two sets of data. First, the homogeneity of variance is examined. The Levene's test for equality of variances is conducted to determine if the samples have equal variances. If the significance value is greater than 0.05, it indicates that the variances are equal, as shown in the first row labelled 'Equal variances assumed'. If the significance value is less than 0.05, it suggests that the variances are not equal, as indicated in the second row labelled 'Equal variances not assumed'. Then, the results of t-test analysis are analysed. In cases where variance equality holds true, if the sig value from t-test is greater than 0.05, it means there is no significant difference between the two sets of data; if sig value is less than 0.05, it implies that there exists a significant difference between them. Finally, it determines which direction this difference lies in:

if t-value is positive, it indicates that group 1 scores significantly higher than group 2 scores; if t-value is negative, it suggests that group 2 scores significantly higher than group 1 scores.

For example, if the significance of Levene's test for homogeneity of variances is greater than 0.05, it indicates that the sample variances are homogeneous, and we should look at the result 'Equal variances assumed'. If the p-value of the t-test is less than 0.05, it suggests that there is a significant difference between the two groups of data.

By conducting t-tests on three measures and the overall attitude, it can be observed that there is no significant difference in scientific attitudes among different grades. I provided a detailed analysis of each specific item in the following sections. However, what differs significantly is that all measures related to Combined interest in science show gender differences, with females consistently scoring lower than males. The subsequent analysis focused on the specific issues within these three measures.

Learning Science in School

Table 6.8

The percentage of students' answers in Learning in science measure

Learning Science in School	Extent of agreement by student (%)				
	1 (Strongly disagree)	2	3	4	5 (Strongly agree)
We learn interesting things in science lessons.	2.4	6.1	35.8	26.4	29.2
I look forward to my science lessons.	2.4	9	27.8	21.7	39.2
Science lessons are exciting.	4.2	10.8	34.4	19.8	30.7
I would like to do more science at school.	3.8	5.2	21.7	29.6	39.6
I like Science better than most other subjects at school.	8	10.4	41.5	15.1	25
Science is boring.	46.7	30.7	18.4	2.4	1.9

77.4% of students believe that science class is not boring, but only 29.2% of students think they can learn something useful in science class. More students choose the neutral option 3 (35.8%). Over half of the students look forward to attending science

class (60.9%) and expect to learn more scientific knowledge at school (69.2%). However, science class fails to excite them as 34.4% of students select the neutral option 3 and 41.5% say 'I like Science better than most other subjects at school.' This indicates that while students have high expectations for science class, they hold a neutral attitude towards the existing curriculum, suggesting dissatisfaction with it. The reasons behind this dissatisfaction could be due to a mismatch between their expectations and what is currently being taught in science class or may require further analysis through interviews if it stems from underperformance in exams related to the subject.

Table 6.9

Result of t-test for Gender difference in Learning Science in School

Measure	Gender	N	Mean	Std. Deviation	t-test for Equality of Means t	Sig. (2-tailed)
Learning science in school	Male	101	3.9336	0.91016	2.268	0.024*
	Female	111	3.6617	0.83532		

* Indicates that the mean difference is statistically significant

From the Table 6.9, it can be seen that boys have a significantly higher interest in science lessons at school compared to girls ($t=2.268$, $p<0.05$), especially when compared to other subjects. Science lessons are able to stimulate boys' enthusiasm more effectively ($M>4.0$). On the other hand, girls have not shown any signs of boredom or finding science boring.

Table 6.10

Results of t-test for gender difference in detailed questions (Learning Science in School)

Learning Science in School	Sex	N	Mean	t-test for Equality of Means t	Sig.(2-tailed)
We learn interesting things in science lessons.	Male	101	3.8119	0.968	0.334
	Female	111	3.6757		
I look forward to my science lessons.	Male	101	4.0495	2.360	0.019*
	Female	111	3.6937		
Science lessons are	Male	101	3.7129	1.145	0.253

exciting.	Female	111	3.5315		
I would like to do more science at school.	Male Female	101 111	4.0297 3.9009	0.867	0.387
I like Science better than most other subjects at school.	Male Female	101 111	3.6337 3.1622	2.888	0.006*
Science is boring.	Male Female	101 111	4.3663 4.0090	2.803	0.006*

* Indicates that the mean difference is statistically significant

According to the Table 6.11, the mean score of higher-grade students is lower than that of lower grade students, but this difference is not statistically significant.

Table 6.11

Results of t-test for grade difference (Learning Science in School)

	Grade	N	Mean	Std. Deviation	t-test for Equality of Means	
					t	Sig. (2-tailed)
Learning Science in School	Lower Higher	86 126	3.7805 3.7986	0.91727 0.85775	-0.147	0.883

Science outside of School

Table 6.12

The percentage of students' answers in Science outside of School

Science outside of school	Extent of agreement by student (%)				
	1 (Strongly disagree)	2	3	4	5 (Strongly agree)
21. I would like to join a science interest group.	4.7	9.4	42.0	21.2	22.6
22. I like watching science programmes on TV or online.	8.0	10.4	34.4	15.6	31.6
23. I like to visit science museums.	7.5	11.3	30.2	17.9	33.0
24. I would like to do more science activities outside school	4.2	6.6	27.8	23.1	38.2
25. I like reading science magazines and books.	7.5	11.8	39.2	18.9	22.6
26. It is exciting to learn about new things happening in science	6.6	15.6	41.0	12.7	24.1

In the study and experience of science outside of school, students demonstrate a neutral and positive attitude. Learning science outside of school is relatively easy and leans towards observing phenomena and hands-on practice, which increases the fun in scientific learning. There is no corresponding evaluation, but interviewed students show a positive attitude towards learning science outside of school. Combining the previous three points reflects that interviewed students are interested in science itself but have a neutral and vague attitude towards current science classes, especially lectures. In other words, interviewed students expect a science practical class without corresponding evaluations or assessments. Alternatively, their attitude towards traditional science classrooms is neutral and vague.

Table 6.13

Results of t-test for gender difference Results of t-test for gender difference in detailed questions (Science outside of school)

	Gender	N	Mean	Std. Deviation	t-test for Equality of Means	
					t	Sig. (2-tailed)
Science outside of school	Male	101	3.6993	0.95447	2.663	0.008*
	Female	111	3.3545	0.92985		

* Indicates that the mean difference is statistically significant

Table 6.14

Results of t-test for gender difference in detailed questions (Science outside of school)

Science outside of school	Sex	N	Mean	t-test for Equality of Means	
				t	Sig.(2-tailed)
I would like to join a science interest group.	Male	101	3.7129	3.084	0.002*
	Female	111	3.2613		
I like watching science programmes on TV or online.	Male	101	3.9010	4.347	0.000*
	Female	111	3.1802		
I like to visit science museums.	Male	101	3.5842	0.095	0.924
	Female	111	3.5676		
I would like to do more science activities outside school	Male	101	3.8119	-.396	0.692
	Female	111	3.8739		
I like reading science magazines and books.	Male	101	3.5743	2.409	0.017*
	Female	111	3.1892		
It is exciting to learn about new things happening in science	Male	101	3.6139	3.501	0.001*
	Female	111	3.0541		

* Indicates that the mean difference is statistically significant

Similar to in-school science, male students exhibit a greater degree of involvement in science courses or activities outside of school compared to their female students ($t=2.663$, $P<0.05$). They demonstrate notably higher levels of interest in science interest groups and keeping up with the latest technological developments as compared to females. It is interesting to note that although there is no significant difference between males and females regarding their willingness to participate, the mean value for females surpasses that of males. Henceforth, this suggests that while females possess a desire to engage in extracurricular scientific activities outside school premises, it may not manifest itself concretely.

Table 6.15

Results of t-test for grade difference Results of t-test for gender difference (Science outside of school)

	Grade	N	Mean	Std. Deviation	t-test for Equality of Means	
					t	Sig. (2-tailed)
Science outside of school	Lower	86	3.6240	0.87424	1.327	0.186
	Higher	126	3.4470	1.00371		

Table 6.16

Results of t-test for grade difference Results of t-test for gender difference in detailed questions (Science outside of school)

Science outside of school	Grade	N	Mean	t-test for Equality of Neans	
				t	Sig.(2-tailed)
I would like to join a science interest group.	lower	86	3.6047	1.424	0.156
	higher	126	3.3889		
I like watching science programmes on TV or online.	lower	86	3.6395	1.111	0.268
	higher	126	3.4444		
I like to visit science museums.	lower	86	3.6163	0.388	0.698
	higher	126	3.5476		
I would like to do more science activities outside school	lower	86	3.9302	0.910	0.364
	higher	126	3.7857		
I like reading science magazines and books.	lower	86	3.5698	2.032	0.043*
	higher	126	3.2381		
It is exciting to learn about new things happening in science	lower	86	3.3837	0.636	0.525
	higher	126	3.2778		

* Indicates that the mean difference is statistically significant

Higher grade students have slightly lower mean scores compared to lower grade students, but there is no significant difference in the overall attitudes towards extracurricular science activities and studying among different grades. However, when it comes to specific items, only in the choice of reading scientific magazines and books do higher grade students show significantly lower mean scores than lower grade students ($t=2.032$, $P<0.05$), shifting from a relatively positive attitude towards a neutral attitude. This may be due to increased academic pressure as grades advance, leading them to prefer other practical and group activities over reading books when selecting extracurricular activities.

Future Participation in Science

Table 6.17

The percentage of students' answers in Future participation

Future participation	Extent of agreement by student (%)				
	1 (Strongly disagree)	2	3	4	5 (Strongly agree)
27. I would like to study more science in the future.	2.8	4.7	29.2	29.2	34.0
28. I would like to study science at university.	7.5	18.4	34.9	17.0	22.2
29. I would like to have a job working with science.	6.6	21.7	40.1	13.7	17.9
30. I would like to become a science teacher.	25.5	30.7	29.7	5.7	8.5
31. I would like to become a scientist.	17.0	26.4	33.5	10.8	12.3

Regarding the willingness to further study science, most students expressed a neutral or positive attitude, while in terms of future career choices, they showed a neutral or negative attitude. This indicates that more students tend to learn science but do not consider it as their lifelong profession. This also aligns with the background of the interviewed students who mostly chose traditional humanities subjects such as history, geography, and biology for their college entrance exams, implying that they may pursue humanities majors in university.

Table 6.18

Results of t-test for gender difference Results of t-test for gender difference (Future participation)

	Gender	N	Mean	Std. Deviation	t-test for Equality of Means	
					t	Sig. (2-tailed)
Future participation	Male	101	3.3168	0.98072	3.324	0.001*
	Female	111	2.8847	0.91196		

* Indicates that the mean difference is statistically significant

Table 6.19

Results of t-test for gender difference Results of t-test for gender difference in detailed questions (Future participation)

Future participation	Sex	N	Mean	t-test for Equality of Neans	
				t	Sig.(2-tailed)
I would like to study more science in the future.	Male	101	4.0198	2.062	.040*
	Female	111	3.7297		
I would like to study science at university.	Male	101	3.6238	4.080	.000*
	Female	111	2.9640		
I would like to have a job working with science.	Male	101	3.4554	3.841	.000*
	Female	111	2.8649		
I would like to become a science teacher.	Male	101	2.4950	1.001	.318
	Female	111	2.3333		
I would like to become a scientist.	Male	101	2.9901	2.778	.006*
	Female	111	2.5315		

* Indicates that the mean difference is statistically significant

In Future participation of science, it can be observed that apart from becoming science teachers, girls show significantly lower levels of enthusiasm in various aspects compared to boys. They exhibit a relatively negative attitude towards scientific careers (including being a science teacher). The stark contrast between their interest in school science classes and their interest in becoming science teachers indicates that teaching science in schools is not an exciting job.

Table 6.20

Results of t-test for grade difference Results of t-test for gender difference

(Future participation)

	Grade	N	Mean	Std. Deviation	t-test for Equality of Means	
					t	Sig. (2-tailed)
Future participation	Lower	86	3.2023	0.93280	1.392	0.165
	Higher	126	3.0143	0.98701		

Table 6.21

Results of t-test for grade difference Results of t-test for gender difference in detailed questions (Future participation)

Future participation	Grade	N	Mean	t-test for Equality of Neans	
				t	Sig.(2-tailed)
I would like to study more science in the future.	lower	86	4.0581	2.240	0.026*
	higher	126	3.7381		

* Indicates that the mean difference is statistically significant

Similar to Science outside of school, there is no significant difference in the overall attitude towards future participation among students of different grades. The only notable decline between higher and lower grade students is observed in the item 'study more science in future'.

6.2.5 ***Self-concept in Science***

Table 6.22

The percentage of students' answers in Self-concept in Science

Self-concept in Science	Extent of agreement by student (%)				
	1 (Strongly disagree)	2	3	4	5 (Strongly agree)
7. I find Science difficult.	15.1	21.7	41.0	17.9	4.2
8. I am just not good at Science.	18.9	21.7	39.6	15.1	4.7
9. I get good marks in Science.	2.4	19.8	47.6	16	14.2
10. I learn Science quickly.	2.4	22.2	43.9	18.9	12.7
11. Science is one of my best subjects.	14.6	27.4	35.8	10.8	11.3
12. I feel helpless when doing Science.	28.8	29.2	32.1	5.7	4.2
13. In my Science class, I understand everything.	9.9	27.8	41	14.6	6.6

In this measure, students tend to choose options 3 and 2 more often. This indicates

that students have a vague evaluation of their own science learning. Combined with the previous item, students like science but hold a wait-and-see attitude towards current science classes. Students' perceptions of their own science learning also come from the classroom and related exams to some extent. As mentioned earlier, most students choose traditional science courses such as physics and chemistry as their science class, while most interviewed students choose history, geography and politics courses. These students believe that traditional science courses such as physics and chemistry are not suitable for them. The neutral attitude towards their own scientific learning reflects the struggle of students' attitudes towards science classes - they want to learn but cannot or do not learn well due to contradictions. However, whether this information about not being able to learn or not doing well comes solely from the student's actual thinking or is mixed with evaluations from teachers and parents, as well as the influence of scientific course exam results, requires in-depth analysis combined with interviews.

Table 6.23

Results of t-test for gender difference Results of t-test for gender difference (Self-concept in Science)

	Gender	N	Mean	Std. Deviation	t-test for Equality of Means	
					t	Sig. (2-tailed)
Self-concept in Science	Male	101	3.4553	0.82999	5.119	0.000*
	Female	111	2.9332	0.63073		

* Indicates that the mean difference is statistically significant

Table 6.24

Results of t-test for gender difference Results of t-test for gender difference in detailed *questions (Self-concept in Science)*

Self-concept in Science	Gender	N	Mean	t-test for Equality of Neans	
				t	Sig.(2-tailed)
I find Science difficult.	Male	101	3.4653	2.792	0.006*
	Female	111	3.0631		
I am just not good at science.	Male	101	3.7624	5.609	0.000*
	Female	111	2.9730		
I get good marks in science.	Male	101	3.4554	3.656	0.000*
	Female	111	2.9640		
I learn Science quickly.	Male	101	3.4455	3.882	0.000*

	Female	111	2.9279		
Science is one of my best subjects.	Male	101	3.1386	4.524	0.000*
	Female	111	2.4324		
I feel helpless when doing Science.	Male	101	3.9208	2.553	0.011*
	Female	111	3.5495		
In my Science class, I understand everything.	Male	101	3.0000	2.725	0.007*
	Female	111	2.6216		

* Indicates that the mean difference is statistically significant

Boys' science self-concept is significantly higher than girls. Girls tend to have predominantly negative responses in almost all questions, while conversely, boys' responses are more positive. The gender difference has statistical significance.

Table 6.25

Results of t-test for grade difference Results of t-test for gender difference (Self-concept in Science)

	Grade	N	Mean	Std. Deviation	t-text for Equality of Means	
					t	Sig. (2-tailed)
Self-concept in Science	Lower	86	3.3219	0.75949	2.188	0.030*
	Higher	126	3.0864	0.77566		

* Indicates that the mean difference is statistically significant

Table 6.26

Results of t-test for grade difference Results of t-test for gender difference in detailed questions (Self-concept in Science)

Self-concept in Science	Grade	N	Mean	t-test for Equality of Means	
				t	Sig.(2-tailed)
I find Science difficult.	lower	86	3.2907	0.410	0.682
	higher	126	3.2302		
I am just not good at science.	lower	86	3.4651	1.279	0.202
	higher	126	3.2698		
I get good marks in science.	lower	86	3.3140	1.408	0.161
	higher	126	3.1190		
I learn Science quickly.	lower	86	3.2326	0.701	0.484
	higher	126	3.1349		
Science is one of my best subjects.	lower	86	2.9070	1.361	0.176
	higher	126	2.6746		
I feel helpless when doing Science.	lower	86	4.0349	3.558	0.000*
	higher	126	3.5159		
In my Science class, I understand everything.	lower	86	3.0116	2.492	0.013*
	higher	126	2.6587		

* Indicates that the mean difference is statistically significant

Although the overall mean of science self-concept measured for lower grade students was significantly higher than that of higher-grade students, by analysing specific issues, it can be found that the main significant differences in self-concept come from feelings of frustration and difficulty in understanding scientific knowledge when learning science, which significantly affect students' self-concept. Of course, there was also a certain degree of decline in other issues for higher grade students.

6.2.6 *Practical Work in Science*

Table 6.27

The percentage of students' answers in Practical work in science

Practical work in science	Extent of agreement by student (%)				
	1 (Strongly disagree)	2	3	4	5 (Strongly agree)
14. Practical work in science is exciting.	2.8	4.7	23.1	20.8	48.6
15. I like science practical work because I can see the actual results rather than literature description.	1.9	5.2	20.8	23.6	48.6
16. Practical work in science is good because I can work with my friends.	3.8	9.4	31.1	22.6	33.0
17. I like practical work in science because I can do it by myself rather than teachers' demonstration.	3.8	6.1	24.1	23.6	42.5
18. I learn science better when we do practical work.	0.9	6.1	25.5	29.7	37.7
19. I look forward to doing science practical.	0.9	3.8	20.3	27.4	47.6
20. Practical work in science is boring.	57.1	24.5	15.1	1.4	1.9

Contrary to self-perception, students show a more positive response towards the practical aspects of science. In subject selection, 82.2% of students align with including experimental practices as part of their science courses. This also reflects their desire to learn science through experiments and hands-on activities. It demonstrates that compared to lectures, students prefer the format of experiments and practical classes, which can better stimulate their interest in learning. As a result, interviewed students perform better in science courses that involve experiments and practical work (67.4%).

Considering the attitude of students towards science courses, it is reasonable to believe that their preference for scientific practices has increased expectations for these classes to some extent.

Table 6.28

Results of t-test for gender difference Results of t-test for gender difference (Practical work in science)

	Gender	N	Mean	Std. Deviation	t-text for Equality of Means	
					t	Sig. (2-tailed)
Practical work in science	Male	101	4.1005	0.77837	0.931	0.353
	Female	111	3.9998	0.79419		

Table 6.29

Results of t-test for gender difference Results of t-test for gender difference in detailed questions (Practical work in science)

Practical work in science	Sex	N	Mean	t-test for Equality of Neans	
				t	Sig.(2-tailed)
Practical work in science is exciting.	Male	101	4.1980	1.586	0.114
	Female	111	3.9640		
I like science practical work because I can see the actual results rather than literature description.	Male	101	4.1188	0.012	0.990
	Female	111	4.1171		
Practical work in science is good because I can work with my friends.	Male	101	3.7822	0.798	0.426
	Female	111	3.6577		
I like practical work in science because I can do it by myself rather than teachers' demonstration.	Male	101	3.9901	0.520	0.604
	Female	111	3.9099		
I learn science better when we do practical work.	Male	101	4.0297	0.819	0.414
	Female	111	3.9189		
I look forward to doing science practical.	Male	101	4.2277	0.852	0.395
	Female	111	4.1171		
Practical work in science is boring.	Male	101	4.3564	0.326	0.745
	Female	111	4.3153		

Although the average scores for girls in the Practical work in science were lower than those for boys, unlike the previous measures, there was no significant difference in scores between the two genders in the Practical work in science.

Table 6.30

Results of t-test for grade difference Results of t-test for gender difference (Practical work in science)

	Grade	N	Mean	Std. Deviation	t-text for Equality of Means	
					t	Sig. (2-tailed)
Practical work in Science	Lower	86	4.1862	0.64341	2.252	0.025*
	Higher	126	3.9533	0.86043		

* Indicates that the mean difference is statistically significant

Table 6.31

Results of t-test for grade difference Results of t-test for gender difference in detailed questions (Practical work in Science)

Practical work in Science	Grade	N	Mean	t-test for Equality of Neans	
				t	Sig.(2-tailed)
Practical work in science is exciting.	lower	86	4.3140	2.703	0.007*
	higher	126	3.9127		
I like science practical work because I can see the actual results rather than literature description.	lower	86	4.3605	2.880	0.004*
	higher	126	3.9524		
Practical work in science is good because I can work with my friends.	lower	86	3.5814	-1.443	0.151
	higher	126	3.8095		
I like practical work in science because I can do it by myself rather than teachers' demonstration.	lower	86	3.9302	-0.192	0.848
	higher	126	3.9603		
I learn science better when we do practical work.	lower	86	4.1628	2.457	0.015*
	higher	126	3.8413		
I look forward to doing science practical.	lower	86	4.4070	3.228	0.001*
	higher	126	4.0079		
Practical work in science is boring.	lower	86	4.5465	2.823	0.005*
	higher	126	4.1905		

* Indicates that the mean difference is statistically significant

Similarly, the mean score of higher-grade students in practical work measure is generally lower than that of lower grade students, which has statistical significance. Specifically, higher grade students have more negative attitudes towards practical work in all but one of the questions, which may be due to the greater pressure of written exams in higher grade grades, causing students to focus more on solving problems and calculations, thus reducing the time and interest spent on practical work.

6.2.7 *Importance of Science*

Table 6.32

The percentage of students' answers in Importance of Science

Importance of Science	Extent of agreement by student (%)				
	1 (Strongly disagree)	2	3	4	5 (Strongly agree)
32. Science and technology is important for society.	1.9	2.8	12.7	14.6	67.9
33. Science and technology makes our lives easier and more comfortable.	1.9	0.9	10.4	19.3	67.5
34. The benefits of science are greater than the harmful effects	2.4	2.4	26.4	30.2	38.7
35. Science and technology are helping vulnerable people.	1.4	4.7	25.0	25.9	42.9
36. There are many exciting things happening in science and technology.	0.5	1.4	19.3	23.6	55.2
37. Scientists have exciting jobs.	5.2	8.0	37.7	22.6	26.4

82.5% of students believe that science is very important to society, 86.8% of students think that technology makes people's lives more convenient, and 78.8% of students consider technology to be exciting with many positive aspects. Students affirm the positive impact of science and technology on society and individuals. From their responses regarding whether the benefits of science outweigh the drawbacks, if it can help disadvantaged groups, and an exciting career in scientific history, it can be seen that most students tend towards a neutral or positive attitude while also maintaining caution towards technology. This reflects the students' dialectical thinking about science itself - recognizing its usefulness and convenience in life but remaining cautious about whether this convenience always outweighs any potential negative consequences.

Table 6.33

Results of t-test for gender difference Results of t-test for gender difference (Importance of Science)

	Gender	N	Mean	Std. Deviation	t-text for Equality of Means	
					t	Sig. (2-tailed)
Importance of Science	Male	101	4.1869	0.68355	0.827	0.409
	Female	111	4.1068	0.72300		

* Indicates that the mean difference is statistically significant

Table 6.34

Results of t-test for grade difference Results of t-test for gender difference (Importance of Science)

	Grade	N	Mean	Std. Deviation	t-text for Equality of Means	
					t	Sig. (2-tailed)
Importance of Science	Lower	86	4.2213	0.59999	1.366	0.173
	Higher	126	4.0929	0.76484		

* Indicates that the mean difference is statistically significant

Table 6.35

Results of t-test for grade difference Results of t-test for gender difference in detailed questions (Importance of Science)

Importance of Science	Grade	N	Mean	t-test for Equality of Neans	
				t	Sig.(2-tailed)
Science and technology are important for society.	lower	86	4.6047	2.273	0.024*
	higher	126	4.3254		
Science and technology make our lives easier and more comfortable.	lower	86	4.6163	1.790	0.075
	higher	126	4.4127		
The benefits of science are greater than the harmful effects	lower	86	3.9186	-1.056	0.292
	higher	126	4.0635		
Science and technology are helping vulnerable people.	lower	86	4.1512	1.311	0.191
	higher	126	3.9683		
There are many exciting things happening in science and technology.	lower	86	4.4186	1.430	0.154
	higher	126	4.2460		
Scientists have exciting jobs.	lower	86	3.6163	0.489	0.626
	higher	126	3.5397		

* Indicates that the mean difference is statistically significant

From the Table 6.33 and

Table 6.34, it can be seen that the overall mean of students' attitudes towards the importance of science is not significantly related to gender and grade, and the overall mean of each group is above 4, so students can recognize the importance of science. Specifically looking at each item of this measure (

Table 6.35), only the 'Science and technology are important for society' item shows that the mean score of higher-grade students is significantly lower than that of lower

grade students. This may be since higher grade students, through learning scientific knowledge, can begin to objectively view the relationship between science and social life, and their attitudes towards the importance of science return to a normal and positive state (M=4.3) from an extreme (M=4.6).

6.2.8 *Correlations between attitude measures*

In concluding my analysis of attitude measures, I investigate correlations between various measures. Table 6.36 displays the Spearson's correlations among the six individual measures, indicating statistically significant correlations across all measures. These findings demonstrate that the measures in the revised science attitude questionnaire assess similar constructs, thus establishing the reliability of the revised science attitude questionnaire.

Table 6.36

Spearman's Correlation among measures

	Measure	Self-concept in Science	Practical work in science	Science outside of school	Future participation	Importance of Science	Combined interest in science
Spearman's rho	Learning Science in School	.554**	.579**	.521**	.562**	.370**	.805**
	Self-concept in Science		.420**	.535**	.489**	.228**	.618**
	Practical work in science			.488**	.398**	.361**	.572**
	Science outside of school				.660**	.498**	.855**
	Future participation					.423**	.860**
	Importance of Science						.513**

**. Correlation is significant at the 0.01 level (2-tailed).

6.2.9 *Findings*

This section tests the scientific attitudes of high school students and analyses their overall performance based solely on the average scores and standard deviations of the total scale and subscales. Such analysis can only provide an overview of the students' scientific attitudes, or perhaps the attitudes of a subset of students in a particular region or school. It cannot represent the scientific attitudes of middle school students in that area, province, or even nationwide, nor can it provide insight into each individual student's specific attitude towards science. Therefore, statistically speaking, the fact that most students demonstrate good scientific attitudes does not imply that there is no portion of students with poorer attitude.

In order to answer research question 3a regarding the current status of high school students' scientific attitudes during the initial stage of curriculum reform, measurement was conducted using a scientific attitude questionnaire, revealing several trends.

Overall, the high school students who participated in the study showed a relatively positive scientific attitude. Their overall scientific attitude was at an above-average level, as indicated by scores above 3 on various scales measuring their attitudes towards science. However, there were also some issues identified. The average score for 'practical work in science' among the tested high school students was 4.0478, while the average score for 'future participation in science' was 3.0906. This suggests that although students are interested in scientific experiments and activities, they have less interest in pursuing careers related to science. Similarly, the average score for Self-concept was only 3.1819. Additionally, the tested students showed greater interest in school-based courses compared to extracurricular ones. Nevertheless, most of them recognized the importance of science in their lives.

Overall, male students demonstrated significantly higher scientific attitudes than female students. Male students scored significantly higher on average in almost all dimensions of the science-related attitude scales, including attitudes towards science and attitudes towards the nature of science. In measures such as 'Leaning science in school', 'Science outside school', 'Self-concept in science', and 'Future participation in

science', the mean scores for male students were significantly higher than those for female students ($P<0.05$). However, there was no statistically significant difference between male and female students' scores in measures of 'Practical work in science' and 'Importance of science', although females had slightly higher mean scores.

The general scientific attitude of higher-grade students shows a decreasing trend compared to lower-grade students, but it is not statistically significant. Correspondingly, the mean difference in 'self-concept in science' and 'practical work in science' is greater than 2, and there is a significant decrease in attitude mean values with increasing grade levels ($P<0.05$).

In addition, as Kind (2007) and Barmby (2008) discussed, the 'Importance of science' is relatively independent and has a low correlation with other measures, indicating that high school students can independently perceive the significance of science in their social lives.

6.3 Student Group Interview Analysis

The focus group consisted of the head teacher and four students from a second-year class in a suburban high school in Tianjin. During the entire interview, I participated as an observer without interfering in the discussions between the teacher and students. The teacher, acting as the moderator, had prior knowledge of the interview outline and added their own understanding to it. They also collaborated with researchers to refine specific questions and content. The four students were informed about several main topics of the interview before participating in group discussions. During the interview, all four students actively expressed their opinions and either agreed or disagreed with other classmates' responses while offering their own perspectives. Therefore, within this group discussion, the teacher's answers were also within my scope of observation.

6.3.1 *Theme one：Reflection to changes on subject choosing*

The first interview topic was about students' experiences in choosing their subjects. At the beginning, the students were a bit nervous and hesitant when expressing their

opinions. However, with guidance from the interviewing teacher, they gradually relaxed and began to express themselves more freely. All students were encouraged to participate in the discussion. The following example is a Q&A session at the start of the group interview.

Interviewer: Today's class meeting is a bit different from usual. Normally, I do most of the talking, but today I want you all to speak up more while I take on the role of asking questions. So first off, does anyone have anything they'd like to say about course selection?

Student A: From the perspective of students, it means that I am good at this subject and I can choose to study it. It's not like before when there were strict divisions between arts and sciences, where I might not be good at certain subjects or couldn't even select a desired course. So, in terms of course selection, I have some preferences, but there are also drawbacks (hesitation).

Interviewer: Well, tell me about it. I just love hearing the downsides, no problem at all. Let's all share and even if there are repetitions, it doesn't matter. Say whatever comes to mind, today we can freely express ourselves.'

Student A: The problem is that the school doesn't have enough resources to provide certain combinations. Some people might have specific preferences, but since the school can't offer them, they can't make a good choice.

Student B: Actually, I managed to find the desired package for myself. However, there are quite a few people around me who still prefer subjects like history, geography, and maybe even physics. In short, it's impossible to satisfy everyone's optimal choice.

Due to the limited selection of courses offered by the school, it is inevitable that not all students' requirements can be met, and some students have to make choices among several subjects. Students also understand the constraints of school resources. In a situation where educational resources are scarce; schools have made their best efforts to provide diverse course packages that meet the needs of most students. After all, everyone has their own unique interests and areas of expertise, so it cannot be expected that every individual receives a curriculum arrangement that perfectly aligns with their preferences. As there are relatively few options for course packages including physics or chemistry provided by the school, there may be cases where some students are unable to select physics or chemistry.'。

During the discussion, the interviewer discovered that students had concerns regarding their choice of physics as a subject. Consequently, the interviewer proceeded to inquire about the students' perspectives and reasons surrounding this matter.

Interviewer: Because as we all know, physics is indeed a difficult subject to study. Of course, from the school's perspective, they would prefer you not to choose physics if possible. So, I wanted to ask the students here about this matter of choosing physics. Do any of you have an initial interest in selecting physics? Or do you know anyone who wants to choose physics and what factors are influencing their decision?

Student A: In reality, there are so many majors to choose from in college. Physics may be difficult to study, but it offers a wider range of options for future school choices. Parents consider this when thinking about their children's future educational opportunities.

Student B: I still think there are pros and cons to both approaches. One is based on grades, if you don't have good grades, you won't get into a top university. The other is based on what majors you can choose in college. Yes, they essentially serve the same purpose, but it's hard to determine which one is better or worse. It all comes down to personal perspective and wisdom.

Student C: I think it's because some classmates may have felt they were doing well in their first year of high school, and since there was more writing involved in the humanities subjects, they may have preferred those. On the other hand, some students like myself were discouraged from taking politics because we were told we wrote too much about it in our essays during our first year, so we ended up choosing science subjects instead.

The students' responses reflect that they have their own thoughts and plans when it comes to choosing subjects, even though they may not be able to fully satisfy their own preferences. However, they can also understand the difficulties faced by teachers and schools. Schools and teachers should seek a better understanding of student feedback at various levels. For example, Student D also mentioned his views on curriculum reform in his response.

I actually considered taking the full humanities track (geography + history + politics) as one of my initial options, but it wasn't my top choice. I've always been good at chemistry, so I wanted to replace one of the humanities subjects with it. As for politics,

I'm not as strong in that subject compared to geography and history. Then I thought, this new curriculum reform is like a software on a computer. It's a good software, but not all schools have the necessary hardware facilities to meet its requirements. Not just our school or even district's top high schools can offer many subjects. My sister attends a prestigious high school in the city and they also don't have all the options available. This curriculum reform is great, but unfortunately, schools are limited by their resources and can only provide a portion of what students may want or need. It's not because of the school itself; rather, it's due to insufficient hardware that hasn't caught up yet while this new software has already arrived. (Student D)

Students choose their subjects mainly based on their own interests, as everyone has different hobbies and strengths. Some students are interested in mathematics, physics, and chemistry, as they enjoy logical thinking and experimental exploration. On the other hand, some students have a strong passion for literature, history, and politics; they enjoy reading, contemplating, and expressing themselves. Additionally, students may also consider the opinions of teachers, family members, and previous senior students. Teachers usually possess extensive educational experience and professional knowledge to provide valuable guidance in choosing a direction. Family members may offer advice based on their child's personality traits and future prospects. Previous senior students share their experiences to help understand the challenges and opportunities in various fields of study. The following student responses reflect this current situation.

Interviewer: What factors would influence your choice if you could choose freely?

Student B: Interest is definitely the top priority, and teachers also have an impact. My family didn't intervene too much because I didn't plan to study science at first since it's difficult. Before the curriculum reform, I planned to choose liberal arts. Senior students' influence exists but not significant.

Student C: I think because I couldn't learn science from the beginning, so my initial idea was to choose all liberal arts courses. However, geography and biology made me hesitate a bit, but in the end, I still chose all liberal arts courses. Another reason is that as an art student, my art teacher suggested that studying all liberal arts might be easier for revision after the joint exam than revising science subjects which are more challenging. When choosing courses at that time, my family did not give me any

opinions or pressure; everything was decided by myself.

Student A: First of all, I really can't handle science subjects because once I touch them, it's over for me. Before making choices about what to study in high school，I had already firmly decided on studying pure humanities subjects in my heart. Later on，it was due to senior students' advice who gave me their thoughts and suggestions about different subjects which caused me to waver again.

However, although these opinions can serve as references, they do not necessarily apply to everyone. Each individual is an independent thinker and decision-maker with their own unique values, interests, and career plans. Therefore, when choosing a major, it is necessary to consider various factors and make a decision that best aligns with one's personal development needs and goals. For example, student A feels that relying too much on the experiences of senior students actually hinders their own decision-making process.

After listening to what they said in the previous session, you may feel that it is completely different from what you had in mind. Then all your motivation to give it a try and test the waters is extinguished. Your mind becomes a chaotic mess, and you don't know if this is the right choice for you or not. Is it too difficult for your first year? Will it become easier in the second year? It seemed promising for the first year, but will I struggle with it in the second year? Now, looking at it, I am confident that my decision was correct. (Student A)

In the early stages of the current curriculum reform, many respondents expressed a lack of confidence in their chosen majors. After all, new course offerings may involve unknown areas or significant changes, making it difficult for them to accurately assess whether the major meets their expectations or fulfils their career development needs. Therefore, seeking help and support from others such as teachers and family members when feeling lost is both normal and advisable. The following student's response effectively explains this inner journey.

I had a significant influence in the field of art, which was related to my own interests. Actually, I didn't ask for any advice from my teachers at that time. However, one teacher did mention once that since I was an art student, they hoped I would choose a pure humanities subject as it would be easier for revision and such. In fact, my parents

didn't put pressure on me but they expressed their preference for me not to study science. However, if I wanted to choose it, then go ahead. From childhood to now, they have always allowed me to make my own choices and haven't interfered too much. Eventually, after considering it thoroughly, I thought studying pure humanities would also be great as I am doing well in it myself. So, in the end, I chose pure humanities. (Student D)

In short, when choosing a subject, one should adhere to their interests and make comprehensive evaluations based on various sources of information. It is also important to maintain an open mindset and accept others' suggestions while making wise decisions after thorough understanding. Courage and patience are required at all times and in all places to explore and find the truly suitable path for personal development on the journey towards pursuing dreams.

6.3.2 ***Theme two：Reflection to the rotating-class-schedule teaching***

Implementing a rotating class schedule allows teachers to better focus on the teaching process, providing them with more time for lesson preparation and instruction, while also fostering student motivation. However, the increased number of classes and student mobility pose new demands for classroom and student management.

Check out this flexible class schedule, it brings a whole new perspective and can tap into students' interests. Today they might be in one classroom discussing a topic with one group of classmates, and tomorrow they could be in another classroom talking about something else with different peers. However, there are also downsides to this approach as it can get pretty chaotic. The school needs more teachers and classrooms to accommodate the rotating schedules, and each classroom shouldn't have too many students so that the teacher can effectively attend to all of them. Otherwise, if there aren't enough teachers or if there are too many students per class, some students may slip through the cracks.(Student D)

From the perspective of teachers, the new teaching mode also imposes higher demands on students.

Just now, what you said is right. The expectations for schools and teachers are quite high, but I feel like everyone has also set high standards for themselves, don't you think? From my perspective, maybe because I believe that we all can't see ourselves clearly, it's possible that we only see the person opposite us! While others may see

teachers and schools, what we might actually see is each other. And I also feel like students are being held to high expectations as well. (Interviewer)

For students, having a high level of self-control is necessary under the rotating-class-schedule system as they frequently switch between different subjects and classrooms. The following dialogue between teachers and students indicates that some students desire a stable learning environment and seek assistance in overcoming their lack of conscientiousness.

Interviewer: Let's say we have a choice between traditional fixed-class teaching with more supervision, or completely free elective courses. Which one would you lean towards?

Student D: I think it's better to have some supervision, sticking to tradition is like what my political teacher said - discipline leads to freedom. Having self-control is important because people from Pingnan are all like that. After all, every time there's a new teacher and in a way, new classmates too. There will always be that sense of fun and novelty, which definitely affects the classroom.

Student C: Yes, actually I think since most people nowadays, especially those of our age group, lack self-discipline to some extent, it's still necessary for someone to keep an eye on us a little bit. It will benefit both the present and the future; whether it's about studying or our outlook on life. In middle school, my self-control was quite poor so being supervised in high school is necessary.

On the contrary, this requirement cultivates their excellent time management skills as well as important qualities such as adaptability to changing environments and task transitions. Through facing diverse experiences like different subjects, teachers, and groupings, students can acquire a broad knowledge background, enhance mental flexibility, and develop comprehensive skills such as problem-solving and collaborative communication. The following answer provides examples to illustrate this situation.

Because I feel that it's me, I enjoy interactive things and don't really like passive lectures telling me what to do or how to approach a learning framework. It's not my style to have everything planned out for me and follow a set pace step by step. I prefer the unknown outcomes and constantly challenging myself. (student A)

Compared with the traditional teaching model where teachers and classes are matched one-to-one, the new modular system may bring some novelty to students

during class, but it could have a negative impact on their ability to concentrate if they lack self-control. At the same time, if a class has too few students, it can also be distressing for them, requiring attention to their psychological well-being.

In some subjects, there may be very few students selected, around seven or eight. The students in these subjects feel particularly lonely because when they enter the classroom, they don't know anyone except for the other six or seven students who also chose that subject. While other classmates leave for their own classes, these seven students remain in the classroom to attend another class. I think it takes time to adapt and may feel uncomfortable after a while due to this isolation.' (Student D) 'In previous years, we had a fixed group of classmates and didn't need to engage in much socializing. Personally, I'm not fond of social interactions, so having the same group of classmates throughout these years was quite nice. It also makes it easier for teachers to manage since sometimes they have difficulty remembering names when students come from different classes. (Student C)

In the traditional mode, teachers and students develop mutual understanding and adaptation through long-term interaction. This process enables teachers to understand students' learning habits and interests, while students can also grasp the teaching style of their instructors. This two-way interaction promotes stable development in classroom teaching. Student D's response excellently exemplifies this process.

It's just the traditional classroom mode, where it's easier for teachers to manage. And I feel that when you spend time with the same teacher, there is a better emotional connection. Although there may be occasional friction, it's different from unfamiliar teachers. With familiar teachers, I would accept and listen to whatever they say. Like in the beginning, I often had some clashes with my political science teacher, but as time went on, I understood what kind of person he was and knew that he wanted what was best for me. So, whatever he said, I would do and listen to because I believed it would be helpful for us. Moreover, if you spend a long time with a teacher like this, they will understand your temperament or character and know how to help you. For example, when Mr. Yao was around, no matter what mistake I made, he wouldn't immediately point out where I went wrong; instead, he would ask why did I do it? But when dealing with other students' mistakes directly without asking questions first might make me angry and unable to comprehend. It's through long-term interaction that personalized teaching can take place. (Student D)

Correspondingly, the familiarity between teachers and students can also potentially influence the teaching process for teachers. Due to their understanding of the teacher, students may be more inclined to seek answers from the teacher rather than exploring solutions on their own. Additionally, teachers may develop certain stereotypes about students which could lead them to overlook or dismiss valuable feedback from these individuals.

I think it's probably because sometimes students tend to nitpick on the flaws of a teacher who has been with them for a long time. They would go to that particular teacher during class reunions and focus on pointing out their weaknesses. It's just that they get easily upset over trivial matters, like if a teacher has a good temper, students may not pay much attention to their management, resulting in occasional chaos in the classroom. (Student C)

6.3.3 ***Theme Three: Attitude towards science and Future***

Students believe that science subjects emphasize practical skills and only intelligent students can excel in them. In the curriculum arrangement of the first and second years of high school, they find it confusing that there is a significant gap in difficulty levels, making it difficult for them to grasp the concept of scientific thinking, which requires strong logical reasoning abilities.

Actually, I think this high school curriculum is not particularly reasonable. I feel that the difficulty level between grades 11 and 12 is quite significant, let's take geography as an example. My younger brother did fairly well in grade 11, but when he entered grade 12, he found the difficulty to be like a whole new book that I had never even heard of before. It was impossible for him to catch up with just one book, and there were more instances like this. As for subjects like science, since the second half of grade 11, I couldn't really understand much even though I tried my best. Maybe it's because I'm not very smart or my brain doesn't work well enough; either way, it was difficult for me. I don't think it has anything to do with others; it's just me who can't handle it. (Student B)

I just can't comprehend this thing called rational thinking. It's like when you have these written words in front of you, you can understand the general meaning to some extent, although not completely. It's what my mom often tells me – lacking rational

thinking and insufficient logical reasoning. Sometimes even when I speak, my lack of logic is evident as I fail to connect one sentence with the next. (Student A)

However, during junior high school, some students are very interested in science. Compared to formulas and problem-solving, experiments and practical applications can stimulate learning interest through visual, auditory, and tactile senses. By hands-on operations and drawing diagrams, they can have a more intuitive understanding of scientific principles and deepen their memory retention.

In middle school, I was quite good at science. We used to do experiments in our dormitory every day during class. The teacher would guide all the students and each pair of students would be given experimental equipment to test on their own. Usually, after completing the experiment in one class period, we would take notes. Maybe it was because the content in middle school was relatively simple that I enjoyed doing this. I believe that incorporating hands-on activities into scientific experiments, including keeping records and drawing diagrams, can be very appealing. It makes people excited and even now I still remember when my chemistry teacher in high school conducted experiments during class. Some experiments produced sparks, smoke, or small explosions which left a strong impression on me. It is probably easier to engage students in such scientific subjects.

Currently, high school students are also facing the issue of choosing a major, which is equally crucial for their future planning. The pressure on students in this regard is immense. There are several reasons why students have not chosen science courses: Firstly, based on their own needs, they believe that studying scientific subjects does not play a significant role in their future development. They may be more interested in humanities and social sciences and tend to pursue careers that involve interacting with people and working in social and humanistic fields. In comparison, subjects like physics and chemistry involved in science courses are not necessary for their career development. From the perspective of students' own abilities, they may not consider that they are capable of learning subjects such as physics and chemistry. Compared to other classmates, my talent in these areas is not outstanding. Additionally, due to pursuing art as well and achieving good results in related exams, considering limited time and energy resources available, it would be easier for me to achieve good grades

by focusing on studying humanities courses after completing the art exam. The following Q&A examples illustrate these reasons.

Interviewer: I have a question that seems to be rarely discussed, which is the impact of future employment on everyone. Does this factor influence your final decision or is it due to the unique situation in our school, where most of you study art and therefore have no other choice?

Student B: Actually, I did consider this, but at that time I was planning for my future. If possible, I wanted to attend a normal university and become an art teacher or something similar. So, it didn't conflict with my subject and course selection.

Student C: Because I feel like I haven't thought that far ahead. Since I'm studying art, I want to be a designer in the future. Initially, when we first had to choose our majors, I wanted to major in physics because I was interested in it. However, later on both my art teacher and my family told me that if I chose science subjects during senior year for intensive training outside of school for art majors, it would be difficult for me to review those science subjects afterwards. Moreover, after studying art for some time, I realized that my performance in science subjects wasn't really good. So resolutely and decisively, I chose humanities instead.

Student A: I chose fine arts because I have already firmly established my future goals! As you know, all of my online space is filled with drawings. I enjoy playing cosplay and I am particularly fond of anime. In the future, I want to work in anime production and contribute to the revitalization of Chinese animation. So, selecting fine arts is purely for learning the technical skills required for creating animations, which aligns perfectly with my interests and hobbies.

Student D: Initially, I wanted to study media communication, so I considered taking science courses. However, I kept hearing that Tianjin's art academy is quite reputable. Besides, I didn't really want to go out-of-town for college as it would be too expensive. But since childhood, drawing has always been a part of me. Moreover, someone in my family graduated from an art academy as well. That's why I decided to pursue fine arts education. As for employment prospects, long ago I had already thought about working in either animation design or costume design field; hence choosing this major doesn't conflict with those aspirations.

6.3.4 *Discussion*

In this study, I selected four students who are interested in science and scientific disciplines (physics, chemistry, biology) for interviews, hoping to find the most authentic feedback from students regarding the implementation of the new curriculum reform. Additionally, I aim to analyse and discuss the reasons and influencing factors behind students' choices or non-choices of science subjects. Through group interviews with these four students, several characteristics can be observed.

Firstly, the four interviewed students believe that the current implementation of curriculum reform is mainly reflected in two aspects. One aspect is the replacement of traditional division between arts and sciences with freedom to choose subjects for college entrance exams. This reform measure allows students to select subjects based on their own interests and strengths, which helps cultivate their comprehensive qualities and personal development. At the same time, it also alleviates the pressure on students from prematurely deciding their future career paths.

On the other hand, the curriculum reform has implemented the flexible class schedule, which has had an impact on classroom teaching by increasing mobility between classes and teachers. The flexible class schedule allows students to choose different teachers based on their own needs, and it also enables teachers to better utilize their expertise in teaching. However, in practical implementation, high levels of mobility within classes may pose adaptation difficulties for some students and present certain challenges for those who require a stable environment or special attention.

Secondly, students are influenced by factors such as family, teachers, and schools when choosing their subjects. The role of the family is crucial in subject selection, as parents often provide advice based on their own experiences and perspectives, hoping that their children chose subjects relevant to future development or beneficial for employment. At the same time, teachers play a guiding role by introducing students to the characteristics and prospects of different subjects in the classroom and offering professional opinions. Schools also meet diverse interests and career planning needs by offering a variety of elective courses.

The influence of different factors on students' choice of subjects may vary. For example, in some families, parents may place more emphasis on the employment advantages of traditional STEM majors while overlooking fields such as arts and humanities. Some teachers may tend to recommend areas they excel at teaching or researching. Meanwhile, certain high schools may prioritize the advantages required for admission to prestigious universities. However, despite these external influences on course selection decisions, most students generally tend to respect and adopt these suggestions based on previous experiences. This is because they believe that those who have already walked this path and experienced success or failure can provide valuable guidance and help them avoid repeating the same mistakes.

It is worth noting that, on the surface, adding choices on subjects may increase overall burden and communication costs. As the number of optional courses increases and conflicts arise in scheduling between each course, considerations for personal time management, academic pressure, and effective communication with parents and teachers become more complex.

Finally, many students fail to translate their interest in science into the motivation to study scientific subjects. This phenomenon may have the following reasons: Firstly, some students are not aware of the important role that scientific disciplines play in their future career choices and prospects. They may lack an understanding of the interconnections between different fields, which prevents them from linking their interest in science with practical applications. Secondly, grades have become a significant reference criterion for many universities during admissions. When faced with choosing a major, many students weigh the relationship between time investment and final grade benefits and exhibit a clear utilitarian tendency. They prioritize options that can bring better job opportunities or higher social recognition while neglecting personal interests and potential development directions.

In addition, there may still exist issues in the education system such as an excessive emphasis on test-taking abilities and a deviation from the spirit of practical exploration. In traditional educational models, knowledge impartation and rote memorization often take precedence, without providing enough space and opportunities for children to

engage in practical exploration and cultivate innovative thinking abilities. These limitations make it difficult for some young people to truly experience the joy and value brought by scientific knowledge.

6.4 Summary

This chapter, as the final chapter of the three-level course framework analysis, attempts to answer Research Question 3 from the perspective of students by analysing the implementation process of curriculum reform. First, a questionnaire survey was conducted to investigate students' scientific attitudes, and the results showed that the overall scientific attitude of high school students was positive, but there were also problems of uneven development. There were gender differences in senior secondary school students' scientific attitudes. The test found that the overall scientific attitude of male students was significantly higher than that of female students. Not only did the gender difference show up in the overall score of scientific attitudes, but also the scores of male students were significantly higher than those of female students in specific dimensions. The scientific attitude of senior students was lower than that of junior students, but the difference was not significant expect for ‘self-concept’ and ‘practical work’. Importance of science can be seen as an individual measure.

Based on the survey questionnaire, a group interview involving four students and one teacher provided more specific insights into students' firsthand experiences with curriculum reform and the role of scientific learning in their future. Students' choices are influenced by various factors, and due to the significant weight placed on college entrance exams in evaluations, pragmatic decision-making becomes the safest choice during the initial stages of reform

In order to address these issues, it requires joint efforts from the entire society to create a positive and open-minded atmosphere that values practical innovation. In educational reforms, it is necessary to introduce more flexible and diversified comprehensive evaluation methods, as well as provide more opportunities for students to engage with and develop a liking for technological innovation activities from an early

age. This effectively stimulated their inner desire to explore the unknown and pursue the pursuit of truth and beauty.

In the concluding and prospective section, I started by addressing three major research questions, integrating the findings and discussions from the three analysis chapters. I further delved into answering these research questions and evaluating the current course reform while attempting to summarize the initial issues of this reform and anticipate future implementations of curriculum reform.

Chapter 7 Discussion and Conclusion

7.1 Overview

The chapter summarizes the findings and discussion in three data analysis chapters based on research questions and attempts to evaluate the course reform from multiple dimensions, following the theoretical basis of literature review. Firstly, I summarised the discoveries and conclusions from three levels of course data analysis, starting with addressing the research questions, and initiate discussions accordingly. Secondly, building upon this foundation, I discussed how these research findings deeply influence and have a lasting impact on curriculum reform. Lastly, dialectical thinking was applied to analyse the strengths and weaknesses of this study as well as explore potential areas for future exploration.

7.2 Research Question 1

What context is the new curriculum taking place and in what ways is the new curriculum distinct with the old one?

Sub-question 1a: What social and political circumstance is the new curriculum taking place?

Sub-question 1b: How do the new curriculum standards translate the official curriculum documents?

Sub-question 1c: in what ways is the new curriculum distinct with the old one?

The occurrence and development of curriculum reform policies are not isolated events. The curriculum reform policy itself, as well as its process, has an inherent trajectory and course of development. The Ministry of Education issued the 'Opinions on Comprehensive Deepening of Curriculum Reform to Implement the Fundamental Task of Cultivating Virtue and Nurturing Talents' in 2014, proposing the development of a core competency system for student development.

This can be seen as the beginning of this round of national curriculum reform.

In 2016, at the conference on the release of research achievements in China's students' development of core competencies, the overall framework and basic connotation of Chinese students' development of core competencies were announced, and curriculum reform based on core competencies was determined (introduced in section 1.2). Simultaneously, this curriculum reform is being carried out in sync with economic, political, and social reforms, making it an integral part of the overall public policy reform ecosystem. The changes in curriculum reflect the transformations occurring within the socio-economic environment. In section 4.2.3, I discuss and address research question 1a regarding the economic, political, and social circumstances surrounding this curriculum reform policy. In order to provide a more comprehensive answer to research question 1 and its sub-questions, I combine the overview of China's curriculum development history presented in Chapter 2 with a comparative analysis of physics curriculum standards and textbooks discussed in section 4.3. This discussion encompasses three aspects: the relationship between inheritance and development in curriculum reform, breakthroughs and innovations made, as well as potential risks involved.

7.2.1 *Inheritance and Development with the previous curriculum reform policies*

First, as reviewed in section 2.3 of the context of large-scale curriculum reform in China, each curriculum reform is constrained by specific policy ecology and influenced by social, political, and economic factors of that time, reflecting the educational value choices and directions of that period. The findings of the political circumstance show the inheritance relationship in curriculum reform is irreversible at the cognitive level. Each curriculum reform policy relies on the content and results of the previous reform as a foundation, with its cognition built upon previous cognitive development. In serving socialist political and economic construction tasks, there was a high degree of unity in curriculum management models, content, and teaching forms, which is consistent with the argument of Donnelly and Jenkins (2001) that the ultimate goal of public policy is to focus on curriculum or instructional reform. It emphasized imparting knowledge in basic subjects and had obvious political functionality orientation (reviewed in section 2.3.1).

As discussed in 4.2.3 of the economic circumstance, with the shift of societal focus to

modernization and economic development after the opening-up reforms, curriculum policies have become increasingly internationalized. Especially with education system changes triggered by political-economic reforms, systematic curriculum transformations have been facilitated. The primary goal of curriculum reform during that period became serving economic development while meeting socio-economic value demands. These phenomena also confirm Bourdieu (2000) and Apple's (2017) views on the relationship between economic development and cultural reproduction in education.

Furthermore, the current curriculum reform also identified similar problems as previous reforms, which mainly manifest in two aspects. Firstly, there is a problem of high concentration of power and bureaucratic control in curriculum management. In the past, the education department strictly regulated the curriculum setting and implementation of schools at all levels, lacking flexibility and space for personalized development (reviewed in 2.3.1, p.24). This centralized management model limits the autonomous choice and innovation of schools, teachers, and students in terms of curriculum content and form (4.2.2, p.126). The statement aligns with Apple's (2019) (reviewed in section 2.3.1, p.30) perspective on power and control of curriculum, while also confirming their viewpoint regarding East Asian countries (Lim & Apple, 2016). Secondly, in terms of curriculum evaluation, there is an urgent need to address the issue of single functionality that excessively emphasizes academic performance and elimination selection. In traditional concepts, only exam scores are emphasized as the sole criterion for measuring student abilities and levels, serving as a basis for selecting outstanding talents (reviewed in section 2.3.3, p.40). However, this assessment method would neglect other aspects of student abilities (such as creativity, teamwork) as well as individual developmental needs.

Finally, as compared in section 4.3.2 and 4.3.4, the curriculum objectives and standards of this course reform also have a certain degree of conformity with the previous reform. The changes in educational objectives in China since the establishment of the new China reflect the response of education to adapt to the development of the times and social progress, as well as to meet the demands for cultivating talents in different eras (reviewed in section 2.3.1). In this process, national educational policies have played a positive guiding role in adjusting talent cultivation goals under new circumstances. Curriculum standards are fundamental documents for national

curricula, which provide basic norms and quality requirements for basic education curricula. They also serve as the basis for textbook compilation, teaching, evaluation, and exam question setting (section 1.2.4). They are essential for national curriculum management and evaluation. In the past, curriculum standards focused on cultivating core competencies and reflected their developmental nature. The old curriculum objectives were developed from three aspects: 'knowledge and skills,' 'processes and methods,' and 'emotional attitudes and values' (Moe, 2003). Core competencies further clarify and refine three-dimensional goals with clearer connotations that are more specific (Table 4.2 and 4.3 in section 4.3.2). Therefore, core competencies not only inherit three-dimensional goals but also develop them beyond their original scope (section 4.3.7).

7.2.2 *Changes and Breakthroughs compared to previous reform policies*

Compared to previous curriculum reforms, this course reform has made some breakthroughs and changes in policies. These changes are both opportunities and challenges. Based on the analysis in Chapter 4 regarding policy documents, curriculum standards, and textbooks, three changes and trends can be observed.

Firstly, beyond the previous educational reforms, the field of education has established a theoretical foundation and identified the values that guide reform policies (section 2.4.3). In the previous curriculum reform, although the introduction of 'quality education' (reviewed in section 2.3.2) has garnered widespread attention and eager anticipation from educational theorists and practitioners, its actual impact is primarily reflected at the level of conceptual understanding. For those engaged in educational practice, core competencies remain a new concept that requires time to truly comprehend, understand, accept, and put into practice (reviewed in section 2.4.4). Therefore, there is still a long way to go in terms of effectively implementing and achieving results with it.

Secondly, new curriculum highlights the incorporation of internationalization into Chinese education and further proposes the construction of school-based curriculum. With the continuous acceleration of globalization, it is crucial address challenges such as diverse cultural backgrounds and knowledge transmission methods from students around the world. At the same time, the construction of school-based curriculum was proposed since the curriculum reform in 2001, but at

that time it was still in a very preliminary stage. Many schools and regions only treated it as an extension and supplement to textbook content, rather than appearing as a relatively independent course (Gu,2004a). Meanwhile, the new curriculum standards in the national curriculum grant school's greater autonomy and place a stronger emphasis on encouraging the implementation of localized national curriculum, particularly in elective series (Table 4.5, Section 4.3.3,).

Moreover, new curriculum not only meets the needs of students' cross-cultural communication and competition but also preserves the essence of excellent traditional Chinese culture. This trend is also shown in experience in curriculum reform of Taiwan which not only emphasizes personal responsibility and knowledge, skills, and attitudes, but also covers citizenship rights and responsibilities (Tsai, 2018a) (reviewed in section 2.4.2, p.47). Since the opening-up policy, China's degree and manner of participation in globalization have changed, so curriculum reform is also influenced by changes in the 'global' discourse system and carries development concepts within specific historical and social contexts.

Finally, new curriculum standards propose an innovation in the evaluation system for college entrance examinations. Based on the theory of quality education and the laws of examination evaluation, this evaluation system creatively integrates the goals of quality education with examination content and aligns the dimensions of quality education assessment with examination requirements (section 1.2.3). In the new curriculum, there is an added component of designing evaluation tasks, which requires teachers to assess students' real learning environment based on their individual differences and the stage of the curriculum, according to core competencies and academic quality levels (Table 4.10, section 4.3.6). It meets the requirements for comprehensive deepening of curriculum reform and strives to transform college entrance examinations from a mere test evaluation into an important carrier for cultivating moral character and a key component of core competencies education. It also ensures systematic alignment with the concepts, goals, and requirements of quality education.

In conclusion, the recent curriculum reform has achieved a series of breakthroughs at the policy level. However, there would be new challenges in implementing the curriculum. It is hoped that these changes can promote China to cultivate a talent pool with comprehensive qualities, creativity, and innovative spirit, and propel the entire society towards higher levels.

7.2.3 *Potential Issues of Implementation.*

In analysing the intentions behind policy reforms and constructing the intended curriculum, I combined my review of the experience of China's curriculum reform development to conclude that there are some potential issues with the implementation of this curriculum reform. I discussed and elaborated on these concerns, and these potential issues were also corroborated by the findings of the two subsequent research questions.

There may be a problem of policy without supporting mechanisms in the process of implementing curriculum reform policies. This means that while there are principles and regulations governing the management process of policy implementation, there is a lack of rigorous and practical working mechanisms to ensure the implementation of relevant work. Additionally, during the implementation of reforms, there might exist a significant amount of unsupervised and unaccountable areas, which results in inadequate support conditions in certain regions compared to the goals set for reform implementation.

Apart from the issue of funding support, training and professional support for curriculum reform may also have an impact on the implementation effectiveness of curriculum reform policies. In the initial stage, training work mainly focuses on general issues and adopts backbone training and centralized discussions. This helps establish a basic understanding of curriculum reform, but as the reform progresses, the focus of training should shift towards addressing practical problems. By analysing and addressing specific issues that arise in practice, it helps implementers understand the core content of curriculum reform. These issues were also identified and considered by Tu (2009) (reviewed in section 2.5.4), who suggested that if different types of training activities and professional guidance are unable to effectively meet the development needs of reform practices, additional problems become evident.

In addition, From the implementation process of curriculum reform, time management has not been formally included in the discussion category, and teachers' working hours seem to be infinitely expandable. This leads to teachers being often busy and even having to give up their rest time to participate in various reform training, collect new curriculum resources, and engage in reform discussions. Because curriculum reform only adds extra workload for teachers and also affects their enthusiasm for engaging in this work. In fact, any new reform activity requires a lot

of time consumption. This potential issue also supported by researches on teachers in reform (Achinstein & Athanases, 2009; Fullan, 2016; Mintrop, 2004).

In summary, Chinese society is undergoing a comprehensive transformation, which involves establishing a market economy system, promoting political democratization and legal development, and constructing a new social structure and power relationship. This transformation has fundamentally changed the policy environment, affected not only the substantive content of the curriculum (such as curriculum systems and basic institutions), but also required adjustments in strategic and technical means within the field of curriculum technology expertise (such as curriculum development and operational mechanisms). It also involves core reflections on curriculum reform in the political and social sphere, challenging and reshaping fundamental issues related to education and human development. Therefore, I attempted to reflect on the fundamental problems faced by education and human development through repositioning the curriculum.'

7.3 Research Question 2

In what ways are high schools and science teachers implementing the new curriculum?

Sub-question 2a: What are school principals' experience and perceptions on the new curriculum implementation?

Sub-question 2b: What are science teachers' experience and reflection on the new curriculum implementation?

Sub-question 2c: What are the factors that affect the implementation of curriculum reform?

The findings from three principal interviews indicate different attitudes and concern of principals towards curriculum reform discussed in section 5.3.4 (p.174). Chen (section 5.3.1) has his own thoughts on curriculum reform but did not deeply engage in reforms based on local policies in Tianjin and experiences from Zhejiang's reforms. Due to a negative attitude towards curriculum reform, Wang (section 5.3.2) returns his focus on exam scores while largely ignoring the impact brought by reforms. Zhou (section 5.3.3) attempts to interpret new curriculum reforms from a perspective of curriculum leadership and seeks new development paths for school-based curricula. Regardless of their attitude towards curriculum reform, principals can proactively or

passively engage in curriculum reform under a top-down reform system.

Findings of principal interviews also demonstrate that there are two sets of curriculum leadership organizations in schools: one is the ‘formal’ organization, and the other is the ‘substantive’ one (section 5.3.4, p.175). The newly established curriculum leadership organization mainly serves the purpose of external display, while the existing teaching leadership organization fulfils its true responsibilities. This corresponds to the two critical dimensions to the principal as a lead learner proposed by Fullan (2016). Additionally, although principals currently prioritize the management model for schools, the trend for future development lies with the emergence and establishment of a distinct position for the curriculum leadership model within schools during ongoing processes implementing curricular reforms. However, due to excessive reliance on an organizational structure with a strong inclination towards management thinking, the practice of ‘putting new wine into old bottles’ limits its effective functioning (section 5.3.2). According to the principal's feedback, there are two reasons for this phenomenon: on one hand, the reason is that the higher-level supervisory departments have overlooked the actual situation of schools. In the process of implementing reforms, the actual conditions of schools would not be considered (Wang’s reflection on changes). On the other hand, it depends on the personal beliefs of the principal. The concept of management is deeply ingrained in their minds, while leadership as a new concept is still relatively unfamiliar to them (Chen’s view on roles of a school principal).

Fullan (2016) believes that principals need to both influence the school's culture towards greater focused collaboration from within and act as "system players" to effectively utilize external resources in building teachers' professional capital. |t is the principal's important responsibility to establish shared values and vision. Although the establishment and dissemination of vision are not yet fully mature, it has already permeated various aspects of the school and become a goal for school principals to strive for. Compared with rules and regulations and decision control individuals, people are more willing to rely on common beliefs and values as guidance for actions as members of the school. Principals do not have much room for adjustment in curriculum planning, but they are all making their utmost efforts. For example, the principals all mentioned in the interviews that the principal also plays a crucial role in developing school-based curriculum and comprehensive practical courses. However, due to the separation and opposition of the two

curriculum management modes in course implementation, it is difficult for principals to truly lead the school's curriculum. Based on the findings of "the intended curriculum" and analysis of principal interviews, I believe that this can be summarized into three factors.

Firstly, there may remain relative lag in the research on curriculum leadership theory and practice. Since the implementation of curriculum reform in China, much attention has been given to related issues such as curriculum implementation, effective teaching, and teacher roles. Many research literature and achievements have emerged (shown in section 2.4.4). However, research on principal's curriculum leadership has been overlooked. In fact, the study of principal's curriculum leadership is still in its infancy and mainly relies on the subjective initiative of individual principals to learn relevant curriculum theories.

Secondly, the influence of the centralized management system has weakened the role and status of principals in curriculum leadership. In the traditional educational management system, principals mainly serve as administrative and instructional leaders, while curriculum development and decision-making power are concentrated in the hands of experts. Despite the emphasis on local and school-based curriculum in the policy (discussed in section 7.2.2), in practical application, even in Zhejiang Province where the new curriculum has been implemented for four years, schools still bear significant management costs and pressure to implement policies. Schools can only mechanically execute instructions from higher authorities. During the implementation process of traditional curricula, principals merely acted as conveyors between national curricula and school-level implementation. This linear and mechanical approach to curriculum management may lead principals to adopt a mindset focused solely on administration without considering curriculum leadership concepts or awareness, resulting in a lack thereof. This is also the reason for the gap between the intended and implemented curriculum, which prevents school management from fully exerting its effectiveness as a policy implementation at the school level (Lee, 2003; Sullanmaa et al., 2019) (Reviewed in section 2.5.4).

Finally, principals and teachers have a lack of understanding of curriculum. In the responses of the interviewed principals and teachers, there is rarely any mention of the content and reform of curriculum. Principals often position themselves as a combination of managers and teachers (section 5.3.1, p.162). Meanwhile, compared to the reforms in curriculum, teachers are more

concerned about changes in teaching content and methods (Theme one, section 5.4.2). In the process of teacher training, only theories related to teaching are taught, and curriculum is usually seen as just a part of teaching (theme two, section 5.3.2 and theme three, section 5.4.2). Therefore, in the minds of teachers and principals at schools, the concept of curriculum is very distant, let alone curriculum leadership. Principals need to integrate and coordinate the efforts of teachers in schools and society to create conditions for change. At the same time, principals also have a crucial responsibility in leading teachers' professional development. They not only need to understand the importance of teachers' professional development but also be aware of their needs in this area and provide appropriate help and support. This consists with Robinson's (2011) summary on the leadership that have effect on students' achievement. Additionally, principals and teachers need to coordinate conflicts and contradictions among different stakeholders within schools during curriculum reform, all of which affect their curriculum leadership.

In section 5.4, I applied the thematic analysis method to code the interview content of 19 teachers from the context perspectives of internal, external, and personal (Figure 5.1). Finally, I organized them into four themes (section 5.4.2). Generally, as similar as principals, teachers' attitudes towards curriculum reform can also be categorized into four types based on their understanding and acceptance of the reform as well as their responses to it (section 5.4.3, p.197). As discussed above, teachers naturally focus on practical teaching processes and assessment procedures. Many teachers lack initiative and enthusiasm in the process of reform. They often feel that they have no say in the design of reforms and cannot participate in decision-making processes, which leads to a lack of motivation for teachers to promote change. Therefore, in such situations, teachers usually can only passively accept instructions and requirements from superiors, making it difficult for them to fully unleash their creativity and professional knowledge. Furthermore, when facing reforms, teachers also worry about the impact on work efficiency. The high time cost required for adapting and implementing new policies and methods may require relearning relevant knowledge and skills, which can cause confusion and pressure for teachers in the short term. Ryder and Banner (2013) revealed that external curriculum reform has effect on teacher's work and development. If work efficiency decreases or problems cannot be resolved promptly, it is easy to

trigger resistance emotions.

Apart from concerns about work efficiency, relatively large-scale reforms can also bring anxiety to teachers in terms of their career development. The emphasis on ‘the rate of admission to prestigious undergraduate programs’ is a commonly observed phenomenon. Teachers may worry about whether they meet the new standards, have enough competitiveness, and how to adapt to changes, which leads to confusion in their career planning (theme three, section 5.4.2). There are also differences in degree, with teachers from urban or more developed areas showing a more positive attitude and being more likely to see these challenges as opportunities. Conversely, other teachers view them as uncertainties that affect their professional evaluation, which can contribute to the imbalance in curriculum reform practices. This phenomenon is particularly evident in the initial implementation of reforms in Zhejiang province, while schools in Tianjin, having learned from the experience of Zhejiang's reforms, might pay more attention to the impact on teacher career development. This phenomenon also echoes Fullan’s (2016) belief that in the process of implementing NCLB in north America, teachers' daily demands can squeeze out significant and sustained improvements, leaving them feeling trapped in coping with intense inspections. At the same time, they have little time for planning, constructive discussions, reflection, and pure calmness.

therefore, there are various problems and concerns during the reform process, and not all teachers can actively engage in it. To better promote the reform process in the field of education, it is necessary to pay attention to and address these issues by giving teachers more voice participation rights, providing support and training opportunities as well as implementing specific measures that are feasible with clear goals.

Finally, from the perspective of teachers' personal experiences, how to perceive the future classroom format and the relationship with students reflects the issue of role transformation that teachers face in curriculum reform. In addition to imparting knowledge, findings indicate that teachers' multiple roles in the new curriculum also increased their teaching burden, directly affecting their enthusiasm for teaching research and the implementation of curriculum reforms (section 5.4.3, p.201). This is like the implementation risks I mentioned in the section 7.2.3, which requires returning corresponding course rights to teachers as the main body of the curriculum.

Ultimately, it aims to transform teachers from passive 'faithful executors' of courses into active regulators or creators who can autonomously participate in course implementation.

7.4 Research Question 3

What is the impact of the new curriculum on high school students' science-related attitudes and how do students experience the curriculum reform?

Sub-question 3a: What is the impact of the new curriculum on high school students' science-related attitudes at the beginning of the curriculum reform?

Sub-question 3b: How do high school students experience the new curriculum?

A questionnaire survey was conducted to investigate students' scientific attitudes. it can be seen that both the questionnaire and its sub-items have relatively high Cronbach's alpha values (table 6.3), indicating a good level of internal consistency in the data. Through the measurement of KMO and factor analysis (table 6.4 & 6,6), the structural validity of the questionnaire is good, and the actual model structure is basically consistent with the design structure. Furthermore, The factor analysis also confirmed the six factors of Kind (2007): *'Learning Science in school, Science outside of school, Future participation in science，Self-concept in science, Practical work in science, and Importance of science'.* Therefore, it can be considered that this model has both theoretical foundations and empirical evidence and is in line with the actual situation of science education in China. It is a comprehensive and systematic theoretical model. This model has important theoretical guidance value for deepening student science education teaching and evaluation work. Findings are conducted from three dimensions: percentage distribution of options, gender differences, and grade differences.

The results showed that the overall scientific attitude of high school students was positive (table 6.7, section 6.3.4), but there were also problems of uneven development. There are gender differences in senior secondary school students' scientific attitudes. The test found that the overall scientific attitude of male students was significantly higher ($P<0.05$) than that of female students (table 6.9, 6.13 & 6.17). Not only did the gender difference show up in the overall score of

scientific attitudes, but also the scores of male students were significantly higher than those of female students in specific dimensions. This also aligns with previous research and expectations regarding gender differences in scientific education (Barmby et al., 2008; Lee, 2003; Wei et al., 2022). The findings show that the general scientific attitude of higher-grade students shows a decreasing trend compared to lower-grade students, but it is not statistically significant. The scientific attitude of senior students was lower than that of junior students, but the difference was not significant expect for ‘self-concept’ and ‘practical work’ (table 6.25 & 6.30). Importance of science can be seen as an individual measure. As Kind (2007) and Barmby (2008) discussed, the 'Importance of science' is relatively independent and has a low correlation with other measures, indicating that high school students can independently perceive the significance of science in their social lives.

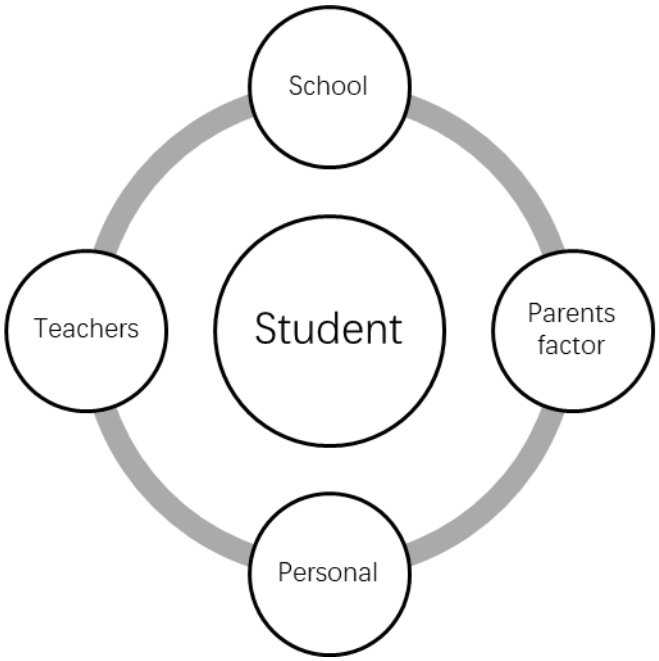
Combining the findings from RQ2, some science teachers, especially physics teachers, indicated that students tend to not choose subjects like physics for further study in college entrance examinations (Theme four, section 5.4.2). Although there is a decrease in students' attitude scores towards science as they progress to higher grades, the mean score remains relatively high (table 6.11, 6.15 & 6.19), indicating a positive attitude towards both school science curriculum and extracurricular scientific activities as well as future plans. Therefore, although some students show interest and enthusiasm for science curriculum, they actively or passively do not choose science subjects for subsequent evaluation.

According to the findings from both the student questionnaires and group interviews, the factors influencing students' subject choices may differ (Shown in Figure 7.1). For instance, within certain families, parents might prioritize the employment prospects associated with traditional STEM majors while overlooking fields like arts and humanities. Some educators may tend to recommend subjects in which they excel at teaching or researching. Additionally, specific high schools may prioritize the advantages necessary for admission into prestigious universities. Nevertheless, despite these external influences on subject selection decisions, most students generally show respect for and adopt these suggestions based on their ‘previous experiences’ (theme one, section 6.3.1). This is because they believe that individuals who have already traversed this path and encountered success or failure can offer valuable guidance to help them avoid

repeating similar mistakes.

Figure 7.1

Factors influencing students' subject choices



It is worth noting that, as same as teacher's perception (theme four, section 5.4.2), adding choices on subjects may increase overall burden and communication costs. As the number of optional courses increases and conflicts arise in scheduling between each course, considerations for personal time management, academic pressure, and effective communication with parents and teachers become more complex (theme two, section 6.3.2).

From the findings of student's future on science (theme three, section 6.3.3), many students fail to translate their interest in science (section 6.2.4) into the motivation to study scientific subjects. This phenomenon may have the following reasons: Firstly, some students are not aware of the important role that scientific disciplines play in their future career choices and prospects. They may lack an understanding of the interconnections between different fields, which prevents them from linking their interest in science with practical applications. Secondly, grades have become a significant reference criterion for many universities during admissions. When faced with choosing a major, many students weigh the relationship between time investment and final grade benefits and exhibit a clear utilitarian tendency. They prioritize options that can bring better job

opportunities or higher social recognition while neglecting personal interests and potential development directions. This also reflects the importance of Fullan's three 'MY' (my Aspirations, Learning, and Belonging) (2016, p. 169) in strengthening student-centred learning. By focusing on individual aspirations while providing personalized instruction within an inclusive environment that fosters belongingness among learners, the educational experience becomes more meaningful, relevant, and engaging for each student involved.

Based on the findings and discussions of RQ1 and RQ2, it can be observed that the status of students in curriculum reform and implementation is gradually improving. Based on the findings of RQ3, I hope to explore methods for comprehensive evaluation of students' core competencies while evaluating the curriculum. This may also enable students to better and more actively participate in the implementation and evaluation of curriculum reform.

7.5 Implications

7.5.1 *Establish a theoretical research system for curriculum reform*

As discussed in 7.2.2, compared to before, there have been many improvements in this course reform, and the formulation of policies is also on the right track. For example, more attention is paid to educational equity, discussions about college entrance examination reforms are being held, and the status of moral education and physical education is being enhanced. However, the operation of China's curriculum reform policy is still very immature in terms of theoretical research.

There is a lack of maturity and clarity in fundamental theoretical research. On one hand, this is manifested by the unclear concepts regarding the basic principles and foundational theories of the reform policy. On the other hand, it is reflected in an inadequate understanding and interpretation of the policy, failing to grasp its essence and core issues. As a result, various participants involved in implementing the policy including experts, scholars, education administrators at all levels, schoolteachers, and the public have a vague understanding of the reform policy. These problems arise from a lack of systematic and clear foundational theoretical research on current curriculum reform policies. If researchers themselves have an unclear understanding of relevant theories or concepts, it becomes understandable that confusion intensifies within practical domains. As Ball (1992) described educational study as *'a growing*

number of concepts which are primarily descriptive, and which are dislocated from any coherent explanatory or predictive framework' (p.1). The achievements of theoretical research can only be validated through practical application. Therefore, I believe it is necessary to organize regular and systematic theoretical and empirical research targeting different curriculum levels. These studies should be interconnected to form regional research teams and groups in order to provide feedback on the implementation of courses and evaluate the effectiveness of reforms.

Moreover, the ability to transform theoretical research into practical applications is not strong. On one hand, it raises questions about whether the achievements of relevant theoretical research are given sufficient attention and effectively utilized. Looking at the operation of China's reform policies, there exists a significant disconnect between research and practice. In my opinion, this precisely reflects the relatively weak theoretical consciousness and competencies among participants in policymaking in our country, as well as the lack of viable mechanisms and work norms that effectively link theory with practice. On the other hand, another reason for the limited ability to translate theoretical research into practice lies in the omission of practical problem-oriented and policy-oriented studies within China's theoretical research.

In summary, there are practical issues in the theoretical research of curriculum reform policies in our country, which indicates that a comprehensive theoretical framework for current curriculum policies has yet to be established. It is necessary to enhance the theoretical literacy of policy participants comprehensively. Theoretical research should not only provide auxiliary research or analysis for policy implementation but also develop systematic, multidimensional, detailed, and in-depth research activities.

7.5.2 *Collaboration and Teaching Culture of the Practical Curriculum*

I discovered an interesting aspect in teacher interviews that was only mentioned by a few teachers, but I found it intriguing. It is the issue of internal culture among teachers, guided by their collaboration in curriculum reform. For example, a chemistry teacher (Z10) from Zhejiang mentioned that due to students choosing biology over chemistry, biology teachers sought deep collaboration with chemistry teachers regarding the impact of curriculum reform on teaching. From the perspective of teachers, this situation was rare before curriculum reform. Teachers are

required to strictly adhere to textbooks, syllabi, and teaching materials when conducting their instructional practices. However, a revolutionary change has silently occurred with the introduction of new curricula. Within this new framework, teachers have transitioned from being mere tools for implementing curriculum to becoming adaptors or even researchers during instruction. As discussed in 7.3, it emphasizes that effective curriculum implementation requires teachers to base their practices on thorough study of the course content itself. This transformation shifts teacher roles from preventive instructors towards active participants who absorb knowledge and motivate others through engaging in research activities; ultimately empowering them as key agents within curriculum implementations.

As Hargreaves (1994, 2019) identified the culture of teaching as two dimensions: one is the content with teachers' shared value, belief and 'the way we doing things around here'; the other is the form of teacher culture, which show changing relations within teacher groups in term of individualistic or collaborated. The new curriculum reform not only empowers teachers with corresponding professional autonomy, but also imposes more requirements on them. Teachers have evolved from passive adaptors in the early stage of curriculum reform to active participants, thereby developing their professional autonomy and consciousness. The enhancement of teachers' professional autonomy and consciousness enables them to effectively control their own ideas and behaviours, forming a 'habit' of reflecting on their professional actions and beliefs. Over time, teachers' curriculum awareness in the new curriculum reform has shifted from negative self-reflection to proactive exploration, leading to the formation of complementary values, beliefs, and normative behaviour habits in their professional practice that reflect individual value choices.

Furthermore, the role of the group in relation to teachers' professional development is that teachers do not solely rely on themselves to develop their professional knowledge and abilities, but also learn from others (such as external experts or colleagues). Teachers are not isolated in forming and improving their teaching strategies and styles; rather, these strategies and styles are largely dependent on 'teaching culture' or 'teacher culture,' which provides meaning, support, and identity for their work. In the teacher community they belong to, teachers can also grow and improve through communication with each other and the influence of intangible cultural atmosphere. At this time, the knowledge they acquire comes from the culture of the group.

Teachers, within their communities, not only gain the necessary professional support for their growth but also acquire a sense of belonging. This psychological sense of belonging allows teachers to constantly receive support from the community and serves as one of the motivational factors that enable them to engage in professional activities despite numerous challenges. Of course, being part of a community means that individuals not only receive help and support but also have certain responsibilities and obligations towards the group. In order to uphold the interests of the community, individuals must adhere to the rules and agreements set by the group and embrace its shared culture.

7.5.3 *Actively engage all participants in the implementation of the curriculum*

Through evaluating three levels of curriculum, I believe that an idealized embodiment of curriculum practice should involve school principals leading and guiding senior teachers in establishing a school culture, developing local curriculum, encouraging active participation from all teachers and students in the formulation of local curriculum, advocating for effective supervision from parents and society, ultimately forming a collaborative reform model with the involvement of families, schools, and communities. Additionally, timely feedback on local reform policies can also be provided. Specifically, this can be manifested in the following aspects:

Firstly, the principal plays a crucial role in community building. To some extent, the principal's leadership philosophy, values, and leadership style directly influence the composition of the community and impact the ‘legitimate identity’ of other members within it. Additionally, due to their position and status, principals also bear responsibilities for organizing, coordinating, and managing curriculum leadership within the community to ensure its smooth daily operation.

Secondly, parents are a potential force lacking organization. Overall, parents are strong supporters of school curriculum reform. However, due to their own limitations, this support can either promote or hinder curriculum reform. At the same time, whether parents can become active participants in the curriculum leadership community depends on the ‘invitation’ from schools. In China, parents have always played a supporting role in school curriculum reform and have been mere observers following school instructions. Even in high-quality schools, parents continue to play such a role. Therefore, if parents want to become members of the community and true

decision-makers in curriculum matters, more effort is needed in practice.

Thirdly, middle-level leaders serve as the link between principals and teachers. In schools, middle-level leaders play a crucial role and sometimes even exercise curriculum leadership power on behalf of principals. Therefore, in some schools, you may not see principals leading anything; instead, busy figures of middle-level leaders can be found everywhere while the role of principals in curriculum leadership is only manifested in thoughts and values. Middle-level leaders have always been the best companions for principals in terms of curriculum leadership. However, the problem lies in the fact that this loyal partnership between middle-level leaders and principals can also give rise to another kind of danger.

Fourth, teachers are an important but untapped force in curriculum leadership. In schools, teachers are crucial leaders. However, this concept has not been given enough attention and the prevailing idea is that principals lead while teachers teach. Teachers' active participation requires guidance from principals or middle-level leaders, but they also need to have sustained benefits in curriculum and teaching research. The assumption that teachers obediently participate in curriculum implementation overlooks their important role as leaders and carries a clear sense of control and management. Teachers should theoretically become curriculum leaders, but they lack legitimate status in practice, which is a significant problem faced by curriculum leadership. If teachers are excluded from curriculum leadership, the effectiveness of principal-led curriculum leadership would also be greatly affected.

Fifth, students are neglected as curriculum leaders. As beneficiaries of school curriculum reform, students have always been overlooked in terms of their involvement in the curriculum. It is unimaginable for schools to consider students as members of the curriculum leadership community. The neglect of student leadership status has its own reasons: firstly, there is a deep-rooted perception that students are merely recipients and learners; secondly, doubts exist regarding students' own leadership abilities; thirdly, there is no clear definition of the scope for student participation in school curricula. Principals' curriculum leadership implicitly operates on these assumptions, rarely considering children and students when it comes to school management, measures, especially curriculum design – effectively excluding them from the process.

Finally，From the operation process of the current curriculum reform policy, it can be seen

that China's education sector is actively advancing towards democratization. It actively attracts different types of policy participants to engage in activities such as policy formulation, research and development, implementation, and evaluation supervision, emphasizing a broad-based participation foundation. This consciously corrects the tradition of power being overly centralized in decision-making. However, elites playing an important role in the curriculum reform policy process, and democratic participation faces issues such as diverse subject power consciousness and limitations on realistic channels.

It is precisely due to the differences that the path of forming a curriculum leadership community is not always smooth sailing. To some extent, the formation of a curriculum leadership community is determined by principals. The principal's concept of curriculum leadership and their recognition of the status of community members have an important impact on the formation of the community. More importantly, it depends on what strategies principals adopt to foster close collaboration among community members based on shared values, achieving ‘harmony in conflict,’ and collectively promoting curriculum development.

7.6 Limitation of this study

Firstly, policy analysis only takes the perspective of national policies into account and fails to conduct regional analysis and comparison based on specific local policies and school-based curriculum. This approach limits the evaluation framework's linearity and hierarchy from a different perspective.

Secondly, it is regrettable that due to the pandemic, face-to-face interviews with all teachers could not be conducted in this study. Face-to-face interviews allow for further probing based on teachers' responses, enabling a deeper understanding of their experience and participation in curriculum reform. It may even provide an opportunity to observe teachers' classroom teaching to some extent.

Thirdly, the lower-than-expected distribution of student questionnaires hampers the generalization of findings and weakens the support for standalone quantitative data analysis, necessitating combined analysis with student interviews. Due to similar reasons, it was not

possible to compare students' scientific attitudes across different schools in various regions.

Lastly, as a former physics teacher involved in this research process, there is always a possibility of reverting back to ‘teacher mode’. Researcher bias is most likely to occur during group discussions with students. To minimize researcher bias, non-participating students act as interview moderators. However, this also resulted in less control over interview content.

7.7 Contribution

Firstly, this thesis enriches the three-level curriculum framework by conducting reviews on courses and theories of curriculum reform, combined with the historical development process of Chinese curriculum. As a result, it develops multiple sub-levels that are suitable for the Chinese curriculum, which has certain theoretical value. I also compared the new curriculum standards and textbooks with old ones to explore the intension of curriculum planners.

Secondly, A mix-method approach was employed in this study to better explore and evaluate the reform at different levels. For the intended curriculum, qualitative documentary analysis of official documents, curriculum standards, and textbooks could raise a context of this reform. For the implemented curriculum, perceptions of principals and teachers come to be vital for evaluation. Thus, interviews and thematic analysis can elicit their in-depth beliefs and attitudes. For the attained curriculum, Quantitative students’ science-related attitudes questionnaire data and qualitative interview data are collected to concrete what students is experiencing and evaluate the reform at the student level.

Finally, based on the scientific attitude assessment tool developed by Kind (2007), a questionnaire for assessing secondary school students' scientific attitudes was constructed. Using this assessment framework and considering the actual situation of high school science education in China, a measurement tool for assessing middle school students' scientific attitudes was developed. After pilot testing and analysis, a five-point Likert scale consisting of 37 items was determined as the scientific attitude assessment tool. The average correlation coefficient and Cronbach's alpha coefficient between items demonstrated good stability and internal consistency of the tool, ensuring its content validity and structural validity. By comparing the differences in scientific attitudes among high school students of different grades and genders, it was confirmed

that the tool had significant empirical effects. This study provides a new empirical research instrument for measuring and evaluating Chinese middle school students' scientific attitudes, which can be widely applied to accurately measure their scientific attitudes during secondary education stage with unique and important applicability in this field.

7.8 Further study

Regarding future-related research, there are two feasible research directions based on my research process and conclusions.

Firstly, the scope of the study can be expanded by choosing to generalize the course to the social level, focusing on vocational education that is at the same high school level as general high schools. This area receives more intervention and influence from society and economic development, and comparisons can be made between the implementation of different courses at the same stage, discussing the prospects for the development of vocational education in China in the future.

Second, since this study was unable to collect post-test data, one or more schools could be selected for a more in-depth longitudinal case study. In addition to the science attitude questionnaire and focus group interviews, teachers could be asked to design teaching evaluation activities, which could include classroom observations, post-class assignments, and exam scores. This would greatly enrich the collected data and lead to more robust and practically significant conclusions.

7.9 Summary

The research on the current round of science curriculum reform in China concludes here. Although a lot of research work has been done, curriculum reform is a massive topic with many aspects deserving further exploration. Moreover, this round of curriculum reform has just begun, and the process of dialectical evaluation of the curriculum will not stop here; it should continue to be part of the subsequent reforms as nourishment.

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Appendix 1: Ethics related documents

Appendix 1.1: Ethics Application Form

Durham University
School of Education
Research Ethics and Data Protection Monitoring Form

Research conducted by Staff and Students in the Department is subject to the standards set out in the Department Code of Practice on Research Ethics. The School of Education Ethics Sub-Committee will assess the research against the British Educational Research Association's *Revised Ethical Guidelines for Educational Research* (2011).

Before the commencement of all research this form should be completed, submitted to the School of Education Ethics Sub-Committee, and their response received. No research can be conducted until ethical approval has been obtained. The Committee will be responsible for issuing certification that the research meets ethical standards and will, if necessary, require changes to the research methodology or reporting strategy.

Appeals against the decision made by the School of Education Ethics Sub-committee should be made by email to ed.ethics@durham.ac.uk. Appeals will be heard by the Faculty Ethics sub-committee.

The application should contain:

a. This completed (and signed) application form;
b. Completed **appendix A**:
    a. A summary of the research proposal. This should be no longer than one A4 page that details:
        i. objectives of the study,
        ii. description of the target cohort / sample,
        iii. methods and procedure of data collection,
        iv. data management, and
        v. reporting strategies;
    b. Outline of the interview schedule / survey / questionnaire / observation protocol or other data collection tools (if applicable depending on the methodology you plan to employ);
c. Completed **appendix B**: the participant information sheet (if applicable), and
d. Completed **appendix C**: the consent form (if applicable).

Templates for the summary of the research proposal, the participant information sheet and the consent form are provided as **appendices A-C** and can be amended as appropriate for the particular application.

Please include all the relevant documents above within one combined document (applications can be accepted in MS Word .doc or .docx format only).

Notes:

- **For non-empirical work** please complete your details on page 2, answer Question 1 and provide further details at Question 11 only. None of the appendices are required.
- **As all applications should be submitted electronically in MS Word format.** Electronic (scanned) signatures should be used (please paste an image of your signature into the declaration section).
- There is a **deadline of 15th of each month** for Ethics applications. Applications received by the 15th of the month will be processed within a 2 week turnaround time i.e. approval letters sent out by the end of the month assuming no queries. Applications received after the deadline will go into the next month.
- **No research should be conducted until ethical approval is obtained.**
- Incomplete applications will be returned without consideration.
- **Please send all documents to ed.ethics@durham.ac.uk, School of Education Research Office, tel: (0191) 334 8403.**

Application for Ethics Approval

Name of applicant	Hao Pang
Email address	hao.pang @durham.ac.uk
Category *[choose from list]*	Postgraduate student - Research programme
If "Other" please specify	
Student ID number *[students only]*	
Programme *[students only – choose from list]*	PhD
If "Other" please specify	
Name of supervisor *[students only]*	Vanessa Kind
Title of research project	An Evaluative study of the New High School Science Curriculum based on 'Core Competencies' in China
Date of start of data collection phase of the research *[must be a future date – no research to be conducted until ethical approval obtained]*	01/07/2017
Is the research funded *[staff only – choose from list]*	No
Name of funder *[staff only]*	N/A
Name of Co-Is if applicable *[staff only]*	N/A
Is this application subject to external ethical review? *[choose from list]*	No
If "yes" please specify who	N/A

FOR OFFICE USE ONLY – Please do not delete this box

Please can reviewers enter the date and select the outcome from the drop-down outcome list below? To open the drop-down list, please select "click here to choose from list". To enter a comment, please click on the yellow highlighted area below and start typing.

Please note that as the review process is anonymous there is no requirement to include initials or signatures in this section.

REVIEWER RESPONSE	REVIEWER COMMENTS
Date:	
Click here to choose from list	

1) a. Does the proposed research project involve data from human participants (including secondary data)?	Yes
b. Is the research project *only* concerned with the analysis of secondary data (e.g. pre-existing data or information records). If yes, please continue with Q6-13	No
c. Is the work non-empirical (e.g. literature review, opinion piece, systematic literature review) If yes, please complete Q11	No
2) Will you provide your informants – prior to their participation – with a participant information sheet containing information about the following: a. The purpose of your research?	Yes
b. The voluntary nature of their participation?	Yes
c. Their right to withdraw from the study at any time?	Yes
d. What their participation entails?	Yes
e. How anonymity is achieved?	Yes
f. How confidentiality is secured?	Yes
g. Whom to contact in case of questions or concerns? *Please attach a copy of the information sheet (template available at **appendix B**) or provide details of alternative approach at Q13 of this form.*	Yes
3) Will you ask your informants to sign an informed consent form? *Please attach a copy of the consent form (template available at **appendix C**) or provide details of alternative approach at Q13 of this form.*	Yes
4) a. Does your research involve covert surveillance?	No
b. If yes, will you seek signed consent post hoc?	Not applicable
5) a. Will your data collection involve the use of sound or image recording devices?	Yes (if yes, please answer Q5b and Q5c below)
b. If yes, will you seek signed consent?	Yes
c. Please specify the type of recording	Audio

6) Will your research report be available to informants and the general public without restrictions placed by sponsoring authorities?	Yes
7) a. Does the research involve unsupervised access to children or vulnerable adults within an activity that is deemed as regulated and would therefore require DBS clearance?	No
b. If yes, can you confirm that DBS clearance is in place or will be in place prior to commencing your research?	Not applicable

8) How will you guarantee confidentiality and anonymity? Questionnaires responses from teachers and students will be collected through online questionnaires system (sent to participants by 'wechat' app) and returned to me directly. Furthermore, student questionnaires will be completed anonymously using unique student identifiers.
9) What are the implications of your research for your informants? The questionnaire for teachers is designed to facilitate respondents to explore, recollect and express their perceptions, views and actual practices in the new science curriculum compared with the old one. There are no direct implications. The questionnaire for students investigates attitudes towards science which helps their teachers to see the effectiveness of their teaching in new curriculum. There are no direct implications for the students.
10) Are there any other ethical issues arising from your research? Both students and teachers will be informed and asked to sign informed consent forms prior to participating in the research. Participants have the right to withdraw at any time. Questionnaires are designed for investigating students' learning science content. There are no other ethical issues.
11) ***For non-empirical projects only***, please provide a brief overview of your project, approx.150 words max. Please include the research aims and objectives and your research approach *(Appendices A to C are not required)*.
12) Will your research either

- Involve the study of an organisation which is proscribed under the terms of the Terrorism Act, or require accessing materials produced by or in support of such an organisation (see https://www.gov.uk/government/publications/proscribed-terror-groups-or-organisations--2)

  Or

- Involve the study of any other current organisation which, as part of its agreed programme, advocates the use of violence to achieve its aims, or require accessing materials produced by or in support of such an organisation.

If you answer yes to either of the above then please contact ed.ethics@durham.ac.uk **for an additional appendix to complete.**

For further information please refer to the University policy https://www.dur.ac.uk/resources/research.office/local/policy/Security-sensitivematerialsFINAL1.0.pdf

13) Please provide any additional information relevant to your application

All questionnaires will be reviewed by two experts in science curriculum to ensure its content validity. In addition, all surveys will be translated into Chinese because all participants targeted are Chinese-speaking.

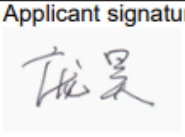
There will be a pilot study with teachers to test the questionnaire design and data collection methods. There will be some changes if there are any comments on the design by pilot study participants.

Declaration

I have read the Department's Code of Practice on Research Ethics and believe that my research complies fully with its precepts.

I will not deviate from the methodology or reporting strategy without further permission from the School of Education Ethics Sub-Committee.

I am aware that it is my responsibility to inform the organisation in which data collection takes place (e.g., school) that ethical approval from the School of Education Ethics Committee has been given, prior to commencing data collection.

Applicant signature* 	Date 13th July 2017
Proposal discussed and agreed by supervisor *[students only]* 	Date 19th July 2017

**To enable electronic submission of applications, electronic (scanned) signatures will be accepted.*
Please note that typed signatures cannot be accepted.

APPENDIX A

Appendix A - Summary of the research proposal

Please include:

a. A summary of the research proposal. This should be no longer than one A4 page that details:
   i. objectives of the study,
   ii. description of the target cohort / sample,
   iii. methods and procedure of data collection,
   iv. data management, and
   v. reporting strategies;
b. Outline of the interview schedule / survey / questionnaire / observation protocol or other data collection tools (if applicable depending on the methodology you plan to employ);

This study is a critical evaluation of the new senior high school curriculum reform in China. The previous curriculum was implemented in the year 2013/2014 in senior high school grades 1 to 3 (ages 16 to 18). The new curriculum and "Gaokao" (university entrance examination) policy will be implemented in Tianjin (my home province) from academic year 2017/2018 replacing the old curriculum, which was based on cultivating students' 'core competencies'.

The samples in this study will be students (16-year-olds) and teachers from Tianjin high school classes. Questionnaire responses from teachers and students will be collected through an online system (made and sent by 'wechat' app). A pilot study with at least five teachers will test the validity of the content and data collection system. Data from teacher interviews and focus groups with students will be recorded by audio with signed consent.

All data will be saved securely in a personal computer. No names and personal contact information will be recorded on questionnaires. In addition, participants are free to withdraw from any process involved in this research. Thus, data will be safely managed and reported in finding and discussion chapters of my PhD thesis with further analysis. Participants' personal information will not appear in any publication arising from the study.

Appendix 1.2: Confirmation Letter of Ethics Approval

Durham University
School of Education

Shaped by the past, creating the future

28/07/2107

Hao Pang
hao.pang@durham.ac.uk

Dear Hao,

An Evaluative study of the New High School Science Curriculum based on 'Core Competencies' in China

I am pleased to inform you that your ethics application for the above research project has been approved by the School of Education Ethics Committee.

May we take this opportunity to wish you good luck with your research.

Yours sincerely,

Nadin Beckmann

Dr Nadin Beckmann
School of Education Ethics Committee Chair

Leazes Road
Durham, DH1 1TA
Telephone +44 (0)191 334 2000 Fax +44 (0)191 334 8311
www.durham.ac.uk/education

Appendix 1.3: Participant Information Sheet

Shaped by the past, creating the future

Durham University
School of Education

APPENDIX B

13/06/2017

Participant Information Sheet

Title: An Evaluative study of the New High School Science Curriculum based on 'Core Competencies' in China

You are invited to take part in a research study of An Evaluative study of the New High School Science Curriculum based on 'Core Competencies' in China. Please read this form carefully and ask any questions you may have before agreeing to be in the study.

The study is conducted by Hao Pang as part of his PhD studies at Durham University.

* This research project is supervised by Vanessa Kind (vanessa.kind@durham.ac.uk) from the School of Education at Durham University.

The purpose of this study is to critically evaluate the new senior high school curriculum reform in China which will implement from academic year 2017/2018.

If you agree to be in this study, you will be asked to have questionnaires about attitudes towards the new curriculum and interviews with further questions about the new curriculum in China.

Your participation in this study will take approximately 30 minutes.

You are free to decide whether or not to participate. If you decide to participate, you are free to withdraw at any time without any negative consequences for you.

All responses you give or other data collected will be kept confidential. The records of this study will be kept secure and private. All files containing any information you give are password protected. In any research report that may be published, no information will be included that will make it possible to identify you individually. There will be no way to connect your name to your responses at any time during or after the study.

If you have any questions, requests or concerns regarding this research, please contact me via email at Hao Pang, hao.pang@durham.ac.uk or by telephone at +8615620081859

This study has been reviewed and approved by the School of Education Ethics Sub-Committee at Durham University (date of approval: 13/06/17)

Hao Pang

Leazes Road
Durham City, DH1 1TA

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www.durham.ac.uk
Durham University is the trading name of the University of Durham

Appendix 1.4: Declaration of Informed Consent

Shaped by the past, creating the future

Durham University
School of Education

APPENDIX C

Declaration of Informed Consent

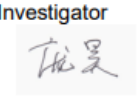
- I agree to participate in this study, the purpose of which is to to critically evaluate the new senior high school curriculum reform in China which will implement from academic year 2017/2018.
- I have read the participant information sheet and understand the information provided.
- I have been informed that I may decline to answer any questions or withdraw from the study without penalty of any kind.
- I have been informed that data collection will involve the use of recording devices.
- I have been informed that all of my responses will be kept confidential and secure, and that I will not be identified in any report or other publication resulting from this research.
- I have been informed that the investigator will answer any questions regarding the study and its procedures. Hao Pang, School of Education, Durham University can be contacted via email: hao.pang@durham.ac.uk or telephone: 008615620081859.
- I will be provided with a copy of this form for my records.

Any concerns about this study should be addressed to the School of Education Ethics Sub-Committee, Durham University via email to ed.ethics@durham.ac.uk.

Date Participant Name (please print) Participant Signature

I certify that I have presented the above information to the participant and secured his or her consent.

Date Signature of Investigator



13th July 2017

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Appendix 2: Modified statements of attitude scale

Table A2.0.1 Modified statements of attitude scale

Attitude Statements	Aspects
1. We learn interesting things in science lessons. 2. I look forward to my science lessons. 3. Science lessons are exciting. 4. I would like to do more science at school. 5. I like Science better than most other subjects at school. 6. Science is boring.	Learning Science in school
1. I find Science difficult. 2. I am just not good at Science. 3. I get good marks in Science. 4. I learn Science quickly. 5. Science is one of my best subjects. 6. I feel helpless when doing Science. 7. In my Science class, I understand everything.	Self-concept in Science
1. Practical work in science is exciting. 2. I like science practical work because I can see the actual results rather than literature description. 3. Practical work in science is good because I can work with my friends. 4. I like practical work in science because I can do it by myself rather than teachers' demonstration. 5. I would like more practical work in my science lessons. 6. I learn science better when we do practical work. 7. I look forward to doing science practical. 8. Practical work in science is boring.	Practical work in Science
1. I would like to join a science interest group. 2. I like watching science programmes on TV or online. 3. I like to visit science museums. 4. I would like to do more science activities outside school. 5. I like reading science magazines and books. 6. It is exciting to learn about new things happening in science.	Science outside of school

1. I would like to study more science in the future. 2. I would like to study science at university. 3. I would like to have a job working with science. 4. I would like to become a science teacher. 5. I would like to become a scientist.	Future participation
1. Science and technology is important for society. 2. Science and technology makes our lives easier and more comfortable. 3. The benefits of science are greater than the harmful effects. 4. Science and technology are helping vulnerable people. 5. There are many exciting things happening in science and technology. 6. Scientists have exciting jobs.	Importance of Science

Appendix 3: Summary of 'Thirteenth Five-year Plan' for National Education Development

Information		Circumstances	Value
Name	'Thirteenth Five-Year Plan' for National Education Development	4. International competition is becoming fiercer and reforms are happening in many countries all over the world. 5. Following the development and adjustment of domestic economy, education is facing challenge. 6. Remarkable achievements have been made in China's education reform and development.	• General educational plan for future five years (2017-2022). • 'Enhance morality and foster talents' • Promote educational equity • Persist in reform and innovation • Leadership of Communist Party of China
Approve Date	10/01/2017		
Issue Agent	Ministry of Education		

Goals	Means-goals
1. The needs and expectations to educational equity of the people.	(1) Guarantee the coverage and quality level of basic public education services. (2) Improve regional imbalance in poverty areas; Increase investment in rural education and implement rural teacher support plan; Increase the enrolment rate of high school education and pre-school education. (3) Accurate financial assistance for students with financial difficulties;
2. Urgent needs of national economic and social development to improve the educational quality.	(1) Implement quality education and strengthen patriotism education. (2) Focus on teacher training and evaluation (3) Deepening the reform of curriculum teaching and examination enrolment system (4) Improve and perfect education evaluation system and quality monitoring system (5) Promote education informatization
3. The long-term needs of the development of national modernization and educational modernization.	(1) Optimize the structure of educational resources allocation (2) Optimize education system structure (3) Optimize talent training structure

Appendix 4: Summary of High School Education Popularization Program (2017-2020)

Information		Circumstances	Value
Name	High School Education Popularization Program (2017-2020)	1. Popularizing high school education is a major measure for China to further improve the overall quality of its people, the competitiveness of its workforce, and build a strong human resources country after popularizing nine-year compulsory education. 2. The gross enrolment rate of high school education reached 87.5% in 2016. However, there are still imbalance in regions and proportion of regular high schools and vocational high schools	• Implement the main responsibility of local government and mobilize all sectors of society to participate. • 'Enhance morality and foster talents' • Promote educational equity • Meet the diverse needs of students • Overall development of general high school education and secondary vocational education
Approve Date	24/03/2017		
Issue Agent	The state Council		

Goals	Means-goals
1. The gross enrolment rate of the whole country and provinces (autonomous regions and municipalities) has reached over 90%	(1) For poverty and rural regions in China, national and local government should give support on expanding educational resources and improving school conditions. (2) For students with economic or physical difficulties, their right to high school education should be protected.
2. the enrolment scales of general high school and secondary vocational education are generally equivalent.	(1) Improve the teaching quality in vocational high schools (2) Set up special subjects to improve the professional skills for future career.

3. School conditions and educational quality should have improved significantly to meet basic needs.	(1) Deepen the curriculum reform by enhancing course selectivity and suitability (2) Strengthen the guidance of students' course selection, further education and employment (3) Promoting the reform of comprehensive evaluation of school education quality (4) Fill up the shortage of subject teachers

Appendix 5: Summary of China Education Modernisation 2035

<table>
<tr><th colspan="2">Information</th><th>Circumstances</th><th>Value</th></tr>
<tr><td>Name</td><td>China Education Modernisation 2035</td><td rowspan="3">1. 2035 is an important time point for China to basically realize socialist modernization.
2. The preparation of ‘China Education Modernization 2035’ is also a practical action for China to actively participate in global education governance, fulfil China's commitment to the UN 2030 Agenda for Sustainable Development, and contribute Chinese wisdom, Chinese experience, and Chinese programs to the development of world education.</td><td rowspan="2">• ‘China Education Modernization 2035’ is China's first medium- and long-term strategic plan with the theme of education modernization.
• It is a programmatic document for advancing education modernization and building an educational power in the new era.</td></tr>
<tr><td>Approve Date</td><td>02/2019</td></tr>
<tr><td>Issue Agent</td><td>The state Council</td></tr>
</table>

Goals	Means-goals
1. Build a modern education system that serves lifelong learning for all. 2. Popularize quality preschool education. 3. Achieve high-quality and balanced compulsory education. 4. Fully popularize high school education. 5. The service ability of vocational education has been significantly improved. 6. The competitiveness of higher education has improved significantly.	1. Strengthen the Party's overall leadership over education 2. Improve the investment support system for education modernization 3. Concentrate on major affairs and rely on departmental and regional collaboration to promote education modernization

7. Children with disabilities have appropriate education. 8. It is to form a new pattern of education governance with the participation of the whole society.	

Appendix 6: Academic level quality description based on core literacy

Core competencies		Academic level quality description 1	Academic level quality description 2*	Academic level quality description 3	Academic level quality description 4**	Academic level quality description 5
Physics idea	Matter Motion and Interaction Energy	Have a preliminary understanding of the physical concepts and laws learned, and can relate them to related natural phenomena and problem solving.	Understand the physical concepts and laws learned, can explain simple natural phenomena, and solve simple practical problems.	Understand the physical concepts and laws learned and their interrelationships, can explain natural phenomena, and solve practical problems.	Understand the concepts and laws of physics and their relationships, correctly interpret natural phenomena, and comprehensively apply the physics knowledge learned to solve practical problems	Clearly and systematically understand physical concepts and laws, can correctly interpret natural phenomena, and can flexibly apply the physical knowledge learned to solve practical problems.
Scientific thinking	Model construction	Able to name some simple physical models learned;	Able to apply common physical models learned in familiar problem situations;	Able to solve simple physical problems with appropriate models according to needs in familiar problem situations;	Convert objects and processes in practical problems into learned physical models;	Convert objects and processes in more complex practical problems into physical models;
	Scientific reasoning	Knowing that reaching a conclusion requires scientific reasoning;	Analyse and reason simple physical problems and get conclusions;	Able to analyse common physical problems, draw conclusions and explain them through reasoning;	Able to analyse and reason comprehensive physical problems, draw conclusions and make explanations;	Able to analyse and reason comprehensive physics problems in new situations, and get correct conclusions and explanations;
	Scientific demonstration	Able to distinguish opinion from evidence;	Able to express opinions using simple and direct evidence;	Able to use evidence appropriately to express one's views;	Able to properly use evidence to support physical conclusions;	Consider the reliability of evidence, reasonable use of evidence;

	Questioning and innovation	Know the importance of questioning and innovation.	Have a sense of questioning and innovation.	Able to question existing ideas and think about physics from different angles.	Raise valid questions to the existing conclusions and analyse and solve physical problems in different ways.	Examine the test conclusions from multiple perspectives and solve physical problems with certain novelty.
Scientific inquiry	Problem	Have problem awareness;	Observe physical phenomena, put forward physical problems;	Analyse physical phenomena, put forward explorable physical problems, and make preliminary guesses;	Analyse relevant facts or conclusions, propose and accurately state probable physical problems, and make valid assumptions;	Able to face the real situation, propose and accurately express explorable physical problems from different angles, and make scientific assumptions;
	Evidence	Able to collect data using simple equipment learned under the guidance of others;	Based on existing scientific inquiry protocols, use the basic equipment learned to obtain data;	Make scientific inquiry plan with the help of others, use basic equipment to obtain data;	Able to formulate scientific inquiry plan and select appropriate equipment to obtain data;	Able to formulate scientific inquiry plans with certain new ideas, flexibly select appropriate equipment to obtain data;
	Explanation	Able to conduct preliminary data sorting;	Able to sort out the data and get preliminary conclusions;	Able to analyse data, find characteristics, form conclusions, and try to explain with existing physical knowledge;	Able to analyse data, find out the rules, form reasonable conclusions, and explain with existing physical knowledge;	Able to analyse data in a variety of ways, find rules, form reasonable conclusions, and make scientific explanations with existing physical knowledge;
	Communication	Have the sense to share results and discuss problems with others.	Able to write a simple report, stating the process and results of scientific inquiry.	Able to write experimental reports and communicate the process and results of scientific inquiry with learned physics terms, diagrams, etc.	Able to write a complete experiment report, communicate and reflect on the process and results of scientific inquiry.	Able to write complete and standardized scientific inquiry reports, communicate and reflect on the process and results of scientific inquiry.

Scientific attitude and responsibility	Nature of science	Recognizing that physics is the description and explanation of natural phenomena;	Recognizing that physics is a description and explanation of natural phenomena based on conscious human inquiry and subject to the test of practice;	Recognize that the study of physics is a creative endeavour based on observation and experiment;	Recognize that the study of physics is a creative work of abstraction of natural phenomena;	Recognize that physics is one of the ways in which humans understand nature, is evolving, relatively durable and universal, but at the same time has limitations;
	Scientific attitude	Have a curiosity about nature, know that learning physics requires seeking truth from facts, and have the willingness to cooperate with others;	Have an interest in learning physics, have a realistic attitude, and cooperate with others;	Strong interest in studying and researching physics, able to seek truth from facts and respect others in cooperation;	Have the intrinsic motivation to study and study physics, insist on seeking truth from facts, and be able to stick to opinions and correct mistakes in cooperation;	Have a strong intrinsic motivation to study and study physics, can consciously resist against the behaviour of seeking truth from facts, can actively participate in communication and play a team role;
	Social responsibility	Know that science, technology, society and environment are interconnected.	Recognize that the research and application of physics will involve ethical and normative issues, and understand the relationship between science, technology, society and environment.	Recognizing that the research and application of physics should take into account the requirements of ethics and norms, and recognizing the responsibility of humanity to protect the environment and promote sustainable development.	Able to understand and evaluate physics research and application according to generally accepted ethics and norms, and have a sense of responsibility to protect the environment, save resources, and promote sustainable development.	When conducting physical research and applying physical results, consciously abide by universally accepted ethics and norms, and develop good habits of protecting the environment, saving resources and promoting sustainable development.

* Academic level quality description 2 is the eligibility criteria for the qualification examination

* Academic level quality description 4 is the eligibility criteria for the graded examination

Appendix 7: Objectives in physics curriculum standard (2003)

Objectives in physics curriculum standard (2003)
A. Knowledge and skills 1. Acquire a solid foundation in physics, comprehending fundamental concepts and laws governing the structure, interaction, and motion of matter, while grasping key perspectives and principles within the field. 2. Recognize the significance and role of experimental work in physics, proficiently mastering essential laboratory techniques, employing basic scientific instruments competently, and independently conducting various physical experiments. 3. Develop an initial understanding of the development process of physics, scientific advancements as well as emerging trends in technology; appreciate how physics influences economic growth and societal development. 4. Foster interdisciplinary connections by acknowledging the interplay between physics and other disciplines; demonstrate familiarity with practical applications associated with physics; endeavour to elucidate natural phenomena encountered in everyday life through relevant knowledge and skillsets from this discipline.
B. Process and Method 1. Engage in the process of scientific inquiry, comprehend the significance it holds, and endeavour to apply the method of scientific inquiry for investigating physical phenomena and validating fundamental laws. 2. Through comprehensive comprehension of physical concepts and laws, grasp the research methodologies employed in physics while recognizing the pivotal role played by physical experiments, models, and mathematical tools in advancing our understanding of this discipline. 3. Demonstrate proficiency in planning and regulating one's own learning journey, independently resolving encountered challenges within physics education, thereby cultivating a sense of self-directed learning capability. 4. Engage in this scientific practice endeavour, endeavour to articulate your own perspectives following thoughtful consideration, and strive to address practical challenges pertaining to production and daily life through the application of physical principles and research methodologies. Possess a discerning ability for questioning, adeptness in information gathering and processing, analytical prowess, problem-solving proficiency, as well as effective communication and collaboration skills.
C. Emotional attitudes and values 1. Demonstrate an appreciation for the awe-inspiring wonders and intricate harmony of nature, fostering a deep curiosity and thirst for scientific knowledge. Be willing to embark on explorations into the enigmatic aspects of nature, embracing both the challenges and joys that come with unravelling its laws. 2. Exhibit a fervent enthusiasm to actively engage in scientific and technological endeavours, possessing a conscious awareness of how physics knowledge can be applied to practical aspects of life and production. Display the courage necessary to delve into physics problems intertwined with daily existence. 3. Embrace unwavering commitment to truth, valuing innovation grounded in empirical evidence while upholding a scientific attitude and spirit. Possess discernment when evaluating whether information disseminated by mass media aligns with scientific principles.

4. Embrace a proactive spirit of collaboration, possess the inclination to engage in meaningful dialogues with peers, exhibit the audacity to uphold righteous perspectives, demonstrate the courage to rectify errors, and foster a strong sense of teamwork.
5. Comprehend and value the pivotal role physics plays in economic and societal progress, actively contemplate pressing physics-related concerns, embrace an ethos of sustainable development, and contribute within one's capacity towards fostering sustainability in society.
6. Display keen interest in both domestic and international scientific and technological advancements, embody a sense of duty and responsibility towards revitalizing China's scientific landscape, while maintaining an unwavering commitment to serving humanity through scientific endeavours.

Appendix 8: Objectives in physics curriculum standard (2017)

Objectives in physics curriculum standard (2017)

On the basis of compulsory education, senior high school physics curriculum should further promote the cultivation and development of students' core quality of physics. Through the study of high school physics, students should achieve the following goals.

Physics idea*

Form material concepts, motion and interaction concepts, energy concepts, etc.; explain natural phenomena and solve practical problems.

Scientific thinking*

1. Have the consciousness and ability to construct models;
2. Use the scientific thinking method, from qualitative and quantitative two aspects of the relevant problems to conduct scientific reasoning, find out the law, form a conclusion;
3. Have the awareness of using scientific evidence and the ability to evaluate scientific evidence, and use evidence to describe, explain and predict research problems;
4. Have a sense of critical thinking, boldly question based on evidence, think from different angles, and pursue scientific and technological innovation.

Scientific inquiry*

1. Have a sense of scientific inquiry, find problems in observation and experiments, and put forward reasonable conjectures and hypotheses;
2. Have the ability to design inquiry plans and obtain evidence, be able to correctly implement inquiry plans, use different methods and means to analyse and process information, describe and explain inquiry results and change trends;
3. Willingness and ability to communicate, accurately describe, evaluate and reflect on the process and results of inquiry.

Scientific attitude and responsibility*

1. Demonstrates a comprehensive understanding of the nature of science;
2. Possesses an innate curiosity and eagerness to acquire knowledge in physics, while actively collaborating with peers and exhibiting respect for diverse perspectives.
3. Capable of articulating evidence-based opinions using logical reasoning, valuing empirical truth over authority figures. Exhibits awareness regarding current scientific trends both domestically and internationally, recognizing that ethical considerations must guide physics research and its applications.
4. Appreciates the interplay between science, technology, society, and environment while embracing responsibility towards environmental protection, resource conservation, and sustainable development.

***** Discipline core competencies

The core literacy of a discipline is the concentrated embodiment of the value of educating students, and is the accurate value concept, essential character and key ability that students gradually form through the study of a discipline. The core competencies of physics mainly includes four aspects: physics idea, scientific thinking, scientific inquiry, scientific attitude and responsibility.

1. **Physics idea**

Physics idea is a basic understanding of matter, motion and interaction, energy, etc., formed from the perspective of physics. It is the distillation and

sublimation of physics concepts and laws in the mind; it is the basis of explaining natural phenomena and solving practical problems from the perspective of physics. Physics idea mainly includes material concepts, motion and interaction concepts, energy concepts and other elements.

2. **Scientific thinking**

Scientific thinking is a way of understanding the essential attributes, internal laws and mutual relations of objective things from the perspective of physics. It is an abstract and generalized process of constructing physical models based on empirical facts. It is the concrete application of methods such as analysis and synthesis, reasoning and demonstration in the field of science. It is the ability and character to question and criticize different opinions and conclusions based on factual evidence and scientific reasoning, to test and revise, and then to put forward creative opinions. Scientific thinking mainly includes the elements of model construction, scientific reasoning, scientific argumentation, questioning and innovation.

3. **Scientific inquiry**

Scientific inquiry refers to the ability to raise physics questions, form conjectures and hypotheses, design experiments and formulate schemes, obtain and process information, draw conclusions and explain based on evidence, and communicate, evaluate and reflect on the process and results of scientific inquiry. Scientific inquiry mainly includes questions, evidence, explanation, communication and other elements.

4. **Scientific attitude and responsibility**

Scientific attitude and responsibility refer to the internal motivation to explore nature gradually formed on the basis of understanding the nature of science, understanding the relationship between science, technology, society and environment; the rigorous, realistic and persistent scientific attitude, and the sense of responsibility to abide by ethics, protect the environment and promote sustainable development. Scientific attitude and responsibility mainly include scientific nature, scientific attitude, social responsibility and other elements.

Appendix 9: Basic contents and main features of Chinese student development key competences

Core Competences		Basic Contents	Main Features
Cultural foundation	Humanistic connotation	Humanistic accumulation	Acquire a comprehensive understanding of the foundational knowledge and scholarly accomplishments in the realm of humanities, both within ancient and modern China as well as internationally. Additionally, demonstrate proficiency in comprehending and applying the methodologies inherent to humanistic thought.
		Humanistic feelings	Cultivate a consciousness centred on human welfare, while upholding and protecting the dignity and worth of individuals; Show care for the survival, advancement, and prosperity of humanity.
		Aesthetic taste	The accumulation of artistic knowledge, skills, and methods; the ability to comprehend and appreciate the diversity of culture and art, while possessing the awareness and fundamental capability to discover, perceive, appreciate, and evaluate beauty; a healthy aesthetic value orientation; an interest in and awareness of artistic expression and creative manifestation, with the capacity to enhance and elevate beauty in life.
	Scientific spirit	Rational thinking	Promote genuine knowledge, demonstrate proficiency in comprehending and mastering fundamental scientific principles and methodologies; Uphold respect for verifiable information and evidence, possess an empirical consciousness and a rigorous intellectual approach; Employ clear logic, apply scientific reasoning to comprehend phenomena, resolve issues, steer conduct, etc.
		Criticize and challenge	Be conscious of potential issues; demonstrate the capacity for independent critical thinking and judgment; exhibit thoughtfulness, the ability to analyses problems from various perspectives and in a dialectical manner, and make informed choices and decisions.
		Dare to explore	Be inquisitive and creative; Demonstrate fearlessness in the face of challenges and maintain a tenacious spirit of inquiry; Embrace bold experimentation and actively pursue effective problem-solving strategies.
Self-development	Learning to learn	Love to Learn and Be Good at Learning	Demonstrate the ability to accurately recognize and appreciate the importance of education, exhibit a positive approach towards learning, and possess a strong enthusiasm for acquiring knowledge; Cultivate effective study habits and acquire mastery over learning techniques that are tailored to one's individual needs; Display self-reliance in

Core Competences		Basic Contents	Main Features
			learning, with an awareness and capability for lifelong education.
		Frequently reflection	Develop the awareness and practice of self-assessment in learning, adept at synthesizing experiences; Demonstrate the ability to select or adapt learning strategies and methods based on varying circumstances and personal context.
		Information awareness	Be proficient in consciously and effectively acquiring, evaluating, identifying, and utilizing information; Possess digital competencies and actively adapt to the evolving trend of social informatization such as 'Internet +'; Demonstrate ethical behaviour in online environments and maintain awareness of information security.
	Healthy life	Respecting life	Understand the significance and value of life; Possess safety awareness and self-protection capabilities; Acquire exercise methods and skills suitable for oneself, and cultivate healthy and civilized behavioural habits and lifestyles.
		Healthy personality	Cultivate positive psychological attributes, such as confidence, self-appreciation, resilience, and optimism. Demonstrate adeptness in self-control and the ability to regulate emotions effectively. Possess the capacity to withstand setbacks and adapt accordingly.
		Self-management	Be capable of accurately comprehending and assessing oneself; Select the appropriate developmental path based on one's own personality and potential; Rationally allocate and utilize time and energy; Persistently take action to accomplish goals, etc.
Social engagement	Responsibility	Social responsibility	Self-respect and self-discipline; exhibiting politeness, receptiveness to criticism, honesty, friendliness, and generosity towards others; demonstrating respect for elders; possessing a heart of gratitude; showing enthusiasm for public welfare and volunteer service. Committed to work with a strong sense of teamwork and mutual support. Capable of taking initiative, fulfilling responsibilities for oneself and others, discerning right from wrong, adhering to rules and laws, actively engaging in civic duties, and exercising civil rights rationally. Advocating freedom and equality while upholding social fairness and justice. Loving and respecting nature with a green lifestyle mindset and commitment to sustainable development concepts and actions.
		National identity	With a strong sense of national consciousness, a deep understanding of national history, and the acceptance of one's own national identity, individuals should be capable of consciously defending national sovereignty, dignity, and interests. Furthermore, they should possess cultural confidence and demonstrate respect for the remarkable

Core Competences		Basic Contents	Main Features
			achievements of Chinese civilization while actively promoting and preserving traditional Chinese culture as well as advanced socialist culture. It is also essential to comprehend the history and illustrious traditions of the Communist Party of China, exhibiting unwavering support for the Party through both consciousness and actions. Additionally, individuals must embrace and consciously practice the core values of socialism while sharing a common ideal in socialism with Chinese characteristics. Lastly, it is imperative to have faith in making relentless efforts towards realizing the Chinese dream of great rejuvenation for the nation.
		International understanding	Demonstrate a global perspective and open-mindedness, comprehend the trajectory of human civilization and worldwide development; demonstrate an ability to appreciate the diversity and distinctions among various cultures globally; actively engage in intercultural exchanges; address global challenges confronting humanity and grasp the significance and value of a community with a shared future for mankind.
	Practice innovation	Labor consciousness	Respect the value of labour, maintain a positive work attitude and cultivate good work habits. Possess practical operational skills and proficiency in specific labour techniques. Demonstrate a commitment to improving and innovating working methods, enhancing labour efficiency through active participation in household chores, production tasks, public service activities, and social initiatives. Embrace the awareness and action of achieving success through honest and lawful labour practices.
		Problem solution	Demonstrate proficiency in identifying and presenting challenges, displaying a keen interest and passion for problem-solving; Exhibit the capability to select and develop rational solutions tailored to specific circumstances and conditions; Possess the competence to navigate complex environments, etc.
		Technology application	Recognize the intrinsic relationship between technology and human civilization; demonstrate a keen interest and readiness to acquire and master technological knowledge; apply engineering thought processes; possess the ability to translate concepts and algorithms into tangible products, as well as enhance and optimize existing entities.

(Core Competencies Research Group, 2016)