

Innovation on Science Curriculum in China

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Background

In order to better respond to the socioeconomic changes, China has carried out a series of education reforms, among which curriculum innovations draws great attention worldwide and plays a significant role in educating 230 million primary and secondary school students.

From 2000, on the basis of experiment in some regions, China has made a lot of endeavors for curriculum reform preparation and implementation. China studied curriculum/learning standards in over 30 countries including those in the USA. Renewing the educational notions and ideas including personal growth, improving the design and implementation of teaching and curriculum with the personal growth and the spirit of new era, China's Ministry of Education (MOE) developed and issued the *Guidelines for the Curriculum Reform of Basic Education* in 2001. Learners' needs as well as the expectations of parents and community were taken care of. After consulting 1200 education, psychology, subject experts and teachers, MOE organized a new circle of design and development of curricula for K-12 education. The new curricula consist national curricula, provincial curricula and school curricula.

The MOE developed national curriculum standards, including all core curricular areas, namely Chinese, math, foreign languages (English as well as Russian, Japanese, French), moral education for grade 1-12, primary science (grade 3-6), integral science (grade 7-9), physics(grade 8-12), chemistry(grade 9-12), biology(grade9-12), history (grade 7-11),geography (7-11). The MOE sets guidance for provincial level curricula designing, yet does not interfere in its autonomy. Likely, each school may set its own school based curriculum. According to teaching hours, national curricula consist of 80%, provincial curricula consists 15% and school curriculum consists 5%.

With permission from MOE, one can edit textbooks according to national curricula. Before selling to school district, the textbooks have to be sent to MOE and got approved by the National School Textbook Examination Commission. So far, there are about 10 sets of textbooks being used in the country. Besides, some publishing houses may just produce two or three kinds of textbooks and are of less influence. Similarly, each province may organize and examine textbooks according to provincial curriculum. But if the textbooks go beyond the province boundary, they have to apply for approval from MOE. A school curriculum is not encouraged to have textbook, instead, various activities could be conducted along with it.

In 2001, over 550 counties started to pilot the new curricula during their compulsory education period, usually beginning from grade 1 and grade 7. By the year 2005, all primary and middle schools in all counties in the whole country's 33 provinces, municipalities and autonomous regions have carried out the new curricula. In 2004, 4 provinces began to pilot the new curricula at their high schools. In 2006 altogether 10 provinces carried out the new high school curricula. Before the year 2008, most of provinces are advised to conduct the new high school curricula.

In primary school period, science standard consist simple or basic daily scientific phenomena,

hands-on ability training, observation of natural environment and life skills. In middle school period, there are integral science and independent subjects. If a middle school offers integral science, it does not offer physics, chemistry, biology, vice versa. But at high school level, there is no subject called science, rather, physics, chemistry and biology are taught respectively nationwide. Comparatively, Science at middle school level can better represent reform opinions of the MOE.

1 Main Contents in Science Curriculum Standard

In the curriculum reform in 2001, the first *National Curriculum Standard of Science Education* for grades 7-9 was issued by the MOE in China. In the following paragraphs, the nature, ideas, objectives and the main contents of science curriculum will be shown in following.

1.1 The Nature and Value of the Science Curriculum

Science curriculum (grades 7-9) is rudimental for the purpose of cultivating scientific literacy of students.

Science Curriculum (grades 7-9), which is on the basis of science curriculum (grades 3-6), will lay the foundation for students to learn other things through studying essential science knowledge and skill. Science curriculum will enable students to go through the process and learn the methods of scientific inquiry, and develop their initial ability of scientific inquiry.

Science curriculum will cultivate the scientific attitude, sensibility and values of students, enable them to understand the nature of science and the relationships of science, technology and society preliminarily, bring up their awareness of the protecting nature and keeping sustainable development and foster the sense of social responsibility.

Science curriculum will lay the foundation for students to develop healthy lifestyles and solve the problems encountered in their individual life, work, decision-making and lifelong development.

Science curriculum is based on the understanding of the essence of the science, and will help students to understand the nature of science

There are natural laws in the world, which can be recognized. Science will help people to understand the nature effectively. Scientific knowledge can reflect human understanding to the nature, by which people can interpret and foresee natural phenomena. Science can be transformed into a technology, and become some kind force to change the world.

Science is an exploration activity by which human beings can explore the nature. Scientific Inquiry involves not only logic and experimental activities, but also creative thinking processes. Scientific knowledge results from human exploring, which is also the crystallization of human wisdom and practice. Science is belonged not only the scientists' career, but also the entire society. Each individual should concern about the development of science and technology.

Science is an open system. Scientific knowledge is relative stable, and also keeps on developing and progressing. It can not solve all the problems, is not an absolute truth and is only applicable in certain conditions and scope. Science emphasizes and obeys the test to scientific theory by experiments.

Science activities should promote social progress, and should be bounded by science morality and community ethics.

The unique role of science curriculum

Compared with separate science subjects, integrated science curriculum tries to go beyond the boundaries of disciplines, has integrative design of the whole system, and pays attention to the relation and penetration among separate science subjects. Integrated science is helpful to students to learn science and the nature, to study scientific method, to develop their inquiry ability, to understand science, technology and society.

1.2 Basic Ideas

“Enhance scientific literacy of all students” is the core idea of the science curriculum.

For all students

Science curriculum (grades 7-9) is part of national nine-year compulsory education. In <National Curriculum Standards of Science Education (grades 7-9) in full-time compulsory education> (Hereinafter referred to as <Standards>) there are basic objectives which should be accomplished for enhancing scientific literacy of students after they finish the nine-year compulsory science education. Science curriculum offers every student fair chances to learn science, no matter what their birth places, nationalities, economic conditions, cultural background, gender, talent and interests.

“Facing all students” also implies taking care of individual difference among students, so that potential of every student can fully be promoted.

For student development

Science curriculum (Grade 7 to 9) is the rudimental course for students to learn science, by which scientific literacy of students should be fully cultivated and the foundation for their lifelong development should be established.

The interest to science is the direct and internal factor for learning science, and is very important for student progress. Science course based on the reality of student life should pay attention to creating the scene for learning, inspiring student’s curiosity and letting them experience the pleasure in science inquiry.

The science education is the interactive process. The objectives should be achieved in science inquiry done by students themselves. In order to develop scientific literacy of students, The teachers should be the organizers, guiders and regulators in students learning according to the <Standards>

Showing the essence of science

The science curriculum should lead students to know the essence of science and realize that there are laws in the nature gradually. Science reflects natural laws in the world concluded by human beings and tested by people’s practice. Also science curriculum should make students know the relations between science, technology and society (STS). Science is a social enterprise which everyone should pay attention to. It is very important for students to develop their scientific attitude, values and good emotion.

Emphasizing science inquiry

Science study has strong relationship with developing scientific literacy of students. One of

science cores is scientific inquiry and the important goal of education is to promote scientific literacy of students. Science curriculum should provide sufficient chances of science inquiry to students, let them enjoy the process in the inquiry in which students study scientific method by their practice, develop the ability needed in inquiry and promote the understanding of science inquiry.

The scientific inquiry is an important way to study science but it is not only one. Science teachers should apply different teaching methods to teach science.

Reflect achievement in modern science

Science is developing rapidly. Science curriculum should reflect the science achievement nowadays and new scientific thought. Students should know some modern science knowledge, new function of modern technology used in the world and the relationship between science and social development. They should learn science knowledge, enhance scientific literacy and set up the ideality for serving society, China and the world.

2 The Text Books for Science Curriculum

The text books for science curriculum are important materials for embodying curriculum objectives and contents in science education, and they are also the tools for student studying and teacher teaching. The basic ideas, curriculum objectives and content standards elaborated in *Standard* can be manifested in the text books. In the following, some things will be discussed on the text books for integrated science curriculum used in middle schools.

2.1 The selection and presentation of the text books

The selection of content of the text books should abide content standards in *Standard* completely. The contents should be selected, which is propitious to understand important and basic concepts and principles, manifest the basic characteristic of science inquiry prominently, develop the ability in science inquiry and know relationship among science、 technology and society.

The selection of text contents in science curriculum should consider roundly the relation between theory and practice, make students understand that science theory originates from practice, be formed in the process of science inquiry and should be applied in technology, life and society areas.

Basic and modern science contents should be selected in the text books, so that students can pay attention to the development of science and technology, open their eyes, know some new scientific thoughts.

The selection of the science contents in the texts should be helpful for science inquiry. The text books should break through the traditional pattern, and provide more opportunity to students for their inquiry. The knowledge taught in class cannot be too much, because it needs time for inquiry study.

The content standard in *Standard* is showed on five aspects, but it does not represent the order of the course contents or the organizational structure of the text books and they need to be created and integrated again while the related text books are written.

The integration of the science text books should try to embody scientific thought whole. It can be considered from three aspects: the unified science concept and principle, the science inquisition and the relation between science, technology and society. Furthermore, the text book should link with the content of following domains: life science, material science, earth science, universe science and space science. For example, basic concepts such as matter, energy and information knowledge penetrate through the text book, systems such as life, material and space should unify and infiltrate into domains of various branches. The spirit of science and humanities should integrate in the education.

The integration of science text books needs not break the boundary of branch domain completely, but in the showing text content, we must pay attention to the connection and integration knowledge and skill in different discipline domains. The integration of science text books should consider students' characteristic of cognition and the request of development. After integrating, science text books should have certain logical structure, but the form of which may be diverse, such as subject oriented, STS oriented, science history oriented, science inquiry oriented, concept development oriented and synthesis of several structural styles.

The presentation of science text books should adapt to students' psychological characteristic, pay attention to stimulating students' interest and motive with vivid and visual things, pay attention to embarking from students' daily life and familiar things, and then returning to the science's application in life and society.

The presentation of text book should give students opportunities to do science inquiry so that they can enlarge knowledge and accept new things.

The presentation of text books should paying attention to opening students eyes, guiding students to carry on inquiry activities (including activities that extend to extracurricular); let students enlarge their visual field in various ways (including in the way trying to solve some science problems unsolved at present); arouse students to participate in the discussions about scientific and social problems and so on.

The compilation of science text books should have consistent style, various forms, lively format and flowing language.

2.2 Three editions of science text books for middle school

The *Science* for middle schools is an integrated science curriculum. According to "*The Outline of Curriculum Reforms in Elementary Education*" issued by MOE, the curriculum of integrated science or separated science should be set up in middle schools, one of which can be chosen by teachers and students in the schools. The integrated science curriculum is juxtaposed with physics, chemistry and biology. According to *Standard*, the integrated science is a basic curriculum for students in middle schools, whose main aim is to promote scientific literacy.

In 2001, there were three editions of science text books from three kinds of publishing house (Shanghai Education Publishing House, Zhejiang Education Publishing House and East China Normal University Publishing House). According to *Standard*, contents in the texts are belonged these aspects: science inquisition (process, method and ability), science knowledge (life, material, Earth, universe and space), and relation of science, technology and society. The books have to embody the basic ideas, accord with the requirement in *Standard*. The books have the following characteristic.

The text contents are diverse for teaching

Compared with *Teaching Outline* issue by the MOE, adopted before this curriculum reform, the goals in *Standard* is expanded greatly, not only having requirements in “knowledge and skill”, but also in “process and method” and “emotion, attitude and value”, which has provided larger space for writing science text books. Writers can edit the text books according to their understandings to the *Standard*, choosing important and basic knowledge, which is good for enhancing student literacy in science. The three text books have different emphasis particularly on technicality, social life, environment or general requirement for junior high students.

Construct text system beyond disciplines

The text book structure is mainly determined by two factors, the logical structure of discipline and the development of student cognition. The key for structure of science books is to construct text system beyond disciplines. Integration of contents should manifest whole scientific thought in the text. There are unified science concepts and principles, the method for science inquiry and the relationship of STS (science, technology and society) in the three books, in which sciences of life, material, earth, universe and space are integrated. Compared with international text books of science, the three text books are constructed respectively by scientific topic oriented, discipline oriented and social life oriented. If text book is constructed by scientific topics or discipline, basic knowledge and skill are emphasized. However, if the text book is constructed by social life, some social issues are stressed, such as problems of water, air, soil and so on, which pays attention to integration of discipline.

The way for text book opening

In the text books, student interest and motive has been exploded by using vivid and magical things. The text books are opening, in which students can be guided to go through science inquiry by observation, experiment, investigation, inquiry, reading and discussion, enlarged their sight, led to participate in various discussions on scientific and social problems. All these facts have demonstrated that science text books in China have reached new level.

Experiences home and abroad have attested repeatedly that there are two difficulties in the implementation of integrated science curriculum in middle schools, which are the text book writing and teacher teaching. Now, the text books in China have developed greatly. But the teacher's teaching should be improved in China.

2.3 An example of the science text book

The following is the content of one kind of text books in science published by Zhejiang Education Press, from which we can find structure of the book obviously.

**Table 1, The Content of Science text books
published by Zhejiang Education Press (Grade 7)**

Grade 7 (Volume One)	Grade 7 (Volume Two)
<p>Chapter One The Science Entrance Section 1 Science Surrounds Us Section 2 Experiment and Observation Section 3 Measurement of Volume and Length Section 4 Measurement of Temperature Section 5 Measurement of Quality Section 6 Measurement of Time Section 7 Science Inquiry</p> <p>Chapter Two Biological Observation Section 1 Biology and Non-biology Section 2 Common Animal Section 3 Common Plant Section 4 the Cell Section 5 Living Things under Microscope Section 6 Structure Levels of Organism Section 7 The Compatibility and Multiple</p> <p>Chapter Three the Earth and Universe Section 1 The Earth We Live on Section 2 Terrestrial Globe and Map Section 3 The Sun and the Moon Section 4 Observe the out of Space Section 5 Phase of the Moon Section 6 Solar Eclipse and Lunar Eclipse Section 7 Exploration of Universe</p> <p>Chapter four Matter's Characteristic Section 1 Melting and Coagulation Section 2 Vaporization and Liquefaction Section 3 Sublimates with sublimates Section 4 Constitution of Matter Section 5 Solubility of Matter Section 6 Acidity and Alkalinity of Matter Section 7 Physics and Chemistry Property</p>	<p>Chapter One Aware of the environment Section 1 Feeling the world Section 2 Occurrence and Transmit of Sound Section 3 Ear and the Sense of hearing Section 4 Light and Color Section 5 Reflection and Refraction Section 6 Eye and Vision Section 7 Gaining and Using of Information</p> <p>Chapter Two Movement and Force Section 1 Movement and Energy Section 2 Mechanical Movement Section 3 Force Section 4 Drawing of Force Section 5 Why the Objects Fall Section 6 Advantage and Disadvantage Section 7 The Newton's first law Section 8 Condition of Two Forces Balance</p> <p>Chapter Three The Continuation of Life Section 1 The cycle of Animals' Lives Section 2 New Birth Section 3 Become Maturity Section 4 Replace Old by New Individual Section 5 The Whole Life of Plant Section 6 Multiplicity of Reproduction</p> <p>Chapter Four The Earth Movement Section 1 Rotation of the Earth Section 2 time of Beijing and "Beijing" Section 3 Earth Movement round the Sun Section 4 Science in Calendars Section 5 Earth Crust and Earthquake Section 6 Plats of the Earth Surface Section 7 Terrain and the Map</p>

**Table 2, The Content of Science text books
published by Zhejiang Education Press (Grade 8)**

Grade 8 (Volume One)	Grade 8 (Volume Two)
<p>Chapter One Water in life Section 1 Where Is Water Section 2 Water's Composition Section 3 Water's Density Section 4 Water's Intensity of Pressure Section 5 Buoyancy in Water Section 6 Decentralization in Water Section 7 Dissolution in Water Section 8 Crystallization in Water Section 9 Use and Protect Water</p> <p>Chapter Two Atmosphere—Earth Coat Section 1 The Atmosphere Section 2 Weather and Temperature Section 3 Pressure of Atmosphere Section 4 Atmospheric Pressure and Living Section 5 Wind Section 6 Why Rains Section 7 How Is the Weather Tomorrow Section 8 Climate and Influence Factor Section 9 Monsoon and Dry Climate in China</p> <p>Chapter Three Adjustments of Life Activity Section 1 Environment Influence to Behavior Section 2 Mysterious Hormone Section 3 Adjustment of Nervous Section 4 Animal's Behavior Section 5 Control the Body Temperature</p> <p>Chapter Four Explore Electric Circuit Section 1 Circuit Diagram Section 2 Measurement of Electric Current Section 3 Conductivity of Material Section 4 Resistance Factors on Conduct Section 5 Use of Rheostat Section 6 Measurement of Voltage Section 7 Relations of I, V, R Section 8 Connection of Electric Circuit</p>	<p>Chapter One Model and Sign of Particles Section 1 Model and Sign Section 2 Matter and Micro Particle Model Section 3 Model of Atomic Structure Section 4 Matter Element Section 5 Element Symbol Section 6 Material Symbol Section 7 Quantity of Elements Symbol</p> <p>Chapter Two Air and Life Section 1 Air Section 2 Oxygen and Oxidation Section 3 Reaction and Conservation Section 4 How Does the Biology Breathe Section 5 The Photosynthesis Section 6 Oxygen and Carbon Cycle Section 7 Pollution and Air Protection</p> <p>Chapter Three Plant and Soil Section 1 What's in the Soil Section 2 Various Soil Section 3 Plant and Soil Section 4 Material Transportation Section 5 Leaf Evaporation and Structure Section 6 Protection Soil</p> <p>Chapter Four Electricity and Magnetism Section 1 Why Can Compass Point Section 2 Electricity Generates Magnetism Section 3 Affecting Electromagnetism Section 4 Electric Motor Section 5 Magnetism Generates Electricity Section 6 Household Electricity Section 7 Use Electricity Safely</p>

**Table 3, The Content of Science text books
published by Zhejiang Education Press (Grade 9)**

Grade 9 (Volume One)	Grade 9 (Volume Two)
<p>Chapter One Exploring Matter Change</p> <p>Section 1 The Change of Material</p> <p>Section 2 Exploring the Nature of Acid</p> <p>Section 3 Exploring the Nature of Alkali</p> <p>Section 4 Several Important Salts</p> <p>Section 5 Searching Laws in Metal Change</p> <p>Section 6 Existence and Change of Organism</p> <p>Chapter Two Material Transformation and Use</p> <p>Section 1 Matter Classification and Use</p> <p>Section 2 Transformation Laws of Material</p> <p>Section 3 Common Material</p> <p>Section 4 Material Development</p> <p>Chapter Three Transformation & Conservation</p> <p>Section 1 Transformation of Energy</p> <p>Section 2 Conversion of Energy</p> <p>Section 3 Simple Machinery</p> <p>Section 4 Kinetic and Potential Energy</p> <p>Section 5 Internal Energy of Object</p> <p>Section 6 Use of Electrical Energy</p> <p>Section 7 Electro-thermal Instruments</p> <p>Section 8 Use of Nuclear Power</p> <p>Section 9 Transformation and Conservation</p> <p>Chapter four Metabolism and Balance</p> <p>Section 1 Animal's Food and Feeding</p> <p>Section 2 Digestion and Absorption</p> <p>Section 3 Transportation in body</p> <p>Section 4 Obtaining Energy</p> <p>Section 5 Dynamical Equilibrium in Body</p> <p>Section 6 Multiplicity of Metabolism</p>	<p>Chapter One Evolving nature</p> <p>Section 1 Origin of Universe</p> <p>Section 2 Solar Formation and Earth Birth</p> <p>Section 3 The Life of Star</p> <p>Section 4 Earth Evolution and Life Birth</p> <p>Section 5 Biological Evolution</p> <p>Section 6 Evolution and Heredity</p> <p>Chapter Two Biology and Environment</p> <p>Section 1 Group and Biological Community</p> <p>Section 2 Ecosystem</p> <p>Section 3 Stability of Ecosystem</p> <p>Chapter Three Health and Environment</p> <p>Section 1 Health</p> <p>Section 2 Threat from Microorganism</p> <p>Section 3 Defense of Body</p> <p>Section 4 Non-infectivity Disease</p> <p>Section 5 Be Care for Your Body</p> <p>Chapter Four Sustainable Environment</p> <p>Section 1 Development and Environment</p> <p>Section 2 Exploration and Use of Energy</p> <p>Section 3 Sustainable Development Comes True</p>

3 Science Teaching in Middle schools

Science teachers should adopt various teaching patterns by inquiry, activity, scene, cooperation and instruction according to the curriculum objectives, teaching environment and student situation. So some principles will be shown in the following paragraphs.

3.1 The principles of science teaching

Concern curiosity and cognition foundation of students

Children's inborn curiosity is the beginning of science study. They are curious about flowers and birds, fish and insects, the sun and the moon, the stars and the sky. This curiosity can be turned into learning desire and behavior if teachers induct well. Furthermore, their imagination is abundant and thinking is active. For example, pupils in middle schools can restore a round plastic ball from a crushing one in their brains. Pupils in middle schools can test certain hypothesis or viewpoint with data.

Encourage students to learn science by practice of brains and hands

The psychology research indicates that forming attitude needs practice, forming skill needs repeating imitation, and obtaining knowledge needs experience accumulation. Students usually depend on their practice of their hands and brains to understand the world, so it is very important to create certain scenes and activities in their studying.

Regard individual differences of students in science learning

In science course, teachers should teach students in accordance with their aptitude and develop them personality, according to their interest, emotion, attitude, knowledge and ability.

Take into account real situation of our students, science teachers should pay attention to the following problems in teaching.

When science teachers deal with relation between the text books and the teaching methods properly, they should make use of the text books, not teach the text books invariably. The former pays attention to not only teaching knowledge but also cultivating ability, scientific attitude and spirit, but the latter emphasizes only the knowledge in the books.

Students should study science in open environment, by which students will face the world and understand science with enthusiasm and interest. The teachers should regard student desire and create a comfortable, harmonious, democratic, friendly environment for their studying. Furthermore, science teachers should guide students to go out classrooms to study in campus, family, society and the nature world. In return, they should also bring some problems in the nature or society back to their classrooms to study.

3.2 Reformation measures for Science Teaching

There are many difficulties in the reformation of science curriculum in middle schools, but science teachers, in teaching experimental areas, still persist in implementing the new curriculum standard. They prepare lessons collectively and create website for science education to overcome the difficulties.

For example, science teachers in Nan Shan, Shenzhen, have summarized that their main experiences for science teaching are adapting to new standard of science curriculum and setting up the teaching and researching groups. Their ways are mainly following

A) The science teaching and researching group takes various modes to study, such as participating diverse training organized by district or school, discussing inside or among groups. Everyone prepares study notebooks to record what has gained from studying. The groups select frequently some teachers to study outside their city, attend training in other places and give reports

in time after return.

B) Based on the school-based research, the science teachers try to be researchers, call for taking classrooms as laboratory or research rooms. The teachers utilize all advantaged resources around and exert collective wisdom, and stress communication among them. It helps to establish active partnership among teachers so as to achieve development and increase efficiently. At the same time, there is a relaxed, open and strong academic atmosphere in group, in which internal mechanism for self-development, self-improvement and self-innovation has been formed basically.

C) The science teaching and researching groups take research activities according to the sequence: "Question--Plan-- Activity --Reflection". The activities are rich and diverse, such as preparing lessons collectively, listening to class, estimating class, teaching feedback, case analysis. The teachers and experts have exchanged ideas each other.

D) Preparing for lessons collectively is a good method for science teaching and researching group which has been existed for several years. In the group, all teachers in the group discuss teaching contents, goals, difficulties and methods together firstly. Then one teacher in the group, usually a professional teacher, prepares a teaching plan initially for the group. Lastly teachers modify it and form their own lesson plan, according to their students as well as their teaching styles. Moreover, teachers need not only take notes after every lesson, but also summarize the gains and losses of the lesson in order to provide reference and guide for future.

E) It is also another efficient activity to listen to and comment on lessons. The teachers in the group can listen to any lesson of each teacher at any time, but they must write a detailed record on estimating the lesson and giving suggestions about this lesson so that they can communicate with others.

F) The science teaching and researching group arranges demonstration lesson, discussion lesson regularly and all teachers in the group are required to participate the different lessons. In the demonstration lessons, there are some new teachers or young teachers to have the lessons. In the discussion lesson, there are different topics, such as new lessons, review lessons, experiment lessons, exercise lessons. Through discussion and exchange of idea, teachers achieve common understanding and find the new way to solve the problem in practice.

G) It is habit to pay attention to research work in the science teaching-researching group. Currently teachers are undertaking a number of research projects such as "Implementation of Science Inquiry under Open Teaching Environment". Each teacher in the group works with certain sub-topics and has achieved some initial results.

H) The science teaching-researching group discusses frequently on some topics and tries to get some conclusion by which teaching can be instructed. For instance, there are these topics: "the instructional design of science teaching", "the growth of young teachers under the new curriculum", "arousing the enthusiasm of the students in lessons", "how to become Professional teachers", "Experimental skills training", "Discussion and demonstration of CAI" and so on.

I) There are certain teaching and researching websites in schools, counties, towns or provinces which are very helpful to science teachers. For example, Pingyang county in Zhejiang province has established nets of "new science curriculum". There are many columns in the website, such as "science research", "teaching resources", "new courses column", "Science and Society", "class

resources", "Theme inquiry", "special judge" and "online exchange". The website provides good curriculum resource for teachers.

4. The Difficulties in Science Teaching

4.1 The experimental areas for actualizing new curriculum

Since the new curriculum "The Science (Grade 7-9)" put into practice in 2001, it has developed but met quite a lot difficulties. Up to 2006, the experimental areas for integrated science practice is shown in the following table.

Table 4, the situation of national large scale experimental areas of science curriculum for Grade 7 to 9 (up to July, 2006)

Experimental area	Students number	Remarks
Shenzhen, Guangdong	200,000 (three grades)	2001-2002, Nanshan, first area 2003, added Baoan 2004, added Luohu, Yantian, Longgang, futian (whole Shenzhen)
Wuhan, Hubei	224,000 (two grades)	2004, whole city
Zhejiang	1590,000 (three grades)	2002, 3 areas 2003, 52 areas 2004, whole province (Since 1991, Zhejiang province has started integrated science)
Lingwu, Ningxia	12,000 (two grades)	2001, whole city
Kaifu, Changsha, Hunan	4,500 (two grades)	2001, Kaifu
Jinchen, Shanxi	34,000 (two grades)	2002, Yangcheng 2003, added three counties 2004, whole city

4.2 Difficulties in implementing science curriculum

Since integrated science curriculum was put into practice, there is continuous critical sound. The criticisms are mainly follows.

The burden is overweight to majority teachers

At present, the burden is overweight to teachers teaching integrated science in the experimental areas. The majority teaches have to teach 3 or 4 classes in a semester, some of which have to in charge of classes for students study and daily life in schools. Because the integrated science curriculum is a new curriculum related to the broad knowledge, quite a lot experiments and inquiry activities. The teachers have to spend much time for preparation lessons, collective preparation, personal preparation, texts study and new knowledge supply. Usually, teachers have to give 15 lessons each week so that they have no time to prepare a lesson fully, which will certainly affect practice quality.

One of biology teacher in Shenzhen Foreign Language School said that preparing lessons was very difficult because he hardly remembered anything in other subjects and he had to spend much time renewing the knowledge. He said “not only had to glance through massive teaching materials, but also had to listen to other teachers’ lessons in order to improve drawback”. Another science teacher in a middle school in Futian said “Our school has started teaching integrated science since 2004, I taught grade 1 last year, grade 2 now and grade 3 next year. I was so busy every day in preparing the lesson”. He also said that in the training held by Shenzhen Education Bureau of Education he was only told the basic structure, logical clue of science text books and he had to search the teaching ways himself. At present, they have adopted the form of the collective preparation for science lessons. They insist on giving a lesson by a science teacher to others once a week. Many teachers indicated that they have taken too much time to prepare a lesson since four separate subjects, such as physics, chemistry, biology and physical geography, are synthesized together.

The professional quality of teachers needs to improve

The existing knowledge of majority teachers cannot satisfy the need of integrated science curriculum. They lack of an overall grasp of the text books. For instance, the science curriculum requests teachers to have understanding in physics, Chemistry, Life science, Globe science as well as astronomy. However present teachers are hardly to adapt the requirement. Every science teacher needs expansion, supplement and enhancement in the knowledge structure and the experimental skills.

“The teachers are only specialized in a single subject, but we have to teach multi-subject curriculum. The knowledge which the teacher possessed is too insufficient to answer student’s questions sometimes”, said Xiao Zhong who is a science teacher in the Futian middle school graduated from the department of chemistry last year. She agrees the viewpoint, which is about “teach what you just acquire” on a website. “I haven mainly studied chemistry in the normal school but as soon as I arrived at the school, I was informed to teach integrated science. I received a week’s training before I give the lesson. I usually prepare a lesson at night and have the lesson next morning” said Xiao Zhong.

Very few outlay and insufficient equipment

Very few outlay and insufficient equipment is also severe problem needed to be solved urgently. The integrated science curriculum emphasizes inquiring and doing experiments. For instance, there are quite a lot experiments for students to do themselves, which is by far insufficient. Moreover, teaching classes are oversized so that students can not do experiments themselves. They have to

“watching experiments” instead of “doing experiments”. Therefore, increasing the number of laboratories or providing enough experiments have become the urgent problems.

Besides the difficulties above, there are some other difficulties, such as connection between senior and middle schools, lack of teaching resources and evaluation and so on.

5 Why Teachers Can't Well Adapt the New Curriculum

Since integrated science curriculum was actualized in 60's, 20th century, countries and areas, where integrated science curriculum was implemented, meet difficulties from the teachers. Teachers who study separate sciences formerly have to teach integrated science instead of physics, chemistry and biology. Thus they have met many problems. It is very important to analyze the reasons why science teachers can not adapt the new curriculum.

5.1 Teachers emotion

For a long time China have implemented separate science curriculum, such as physics, chemistry and biology, which is characterized mainly by knowledge-center viewpoint in the middle schools. The important point in knowledge-center curriculum is to have curriculum system based on separate subjects. Because the subject system has the simple harmonious form and clear logical clue, people call it as “the absolute beauty”. When the “absolute beauty” system is broken by integrated science curriculum, teachers who have received professional training will think that the artwork they love has been broken by integrated science.

The knowledge—center curriculum in middle schools is suited to the curriculum set in universities and is convenient for teachers graduated from universities, which is another point of knowledge-center curriculum. The teachers in middle schools are fostered mainly according to the pattern of separate subjects. They have once studied hard to the separate subjects and even enjoyed the system. Now they have to give up their familiar system and adapt a new system which is not based on separate subjects. Thus, they have resistance mood in their heart to integrated science. Some teachers who are good at teaching separate science but their visual fields are not wide enough, are more against integrated science curriculum.

5.2 The change of knowledge structure

The people often use “a barrel of water and a glass of water” to compare the relation of knowledge instruction between teacher and students, which has also been regarded as the main reason why separate subject teachers have difficulties to teach integrated science curriculum. However, teachers have difficulties mainly from the knowledge structures not the knowledge quantity. Compared with physics, chemistry and biology, the knowledge structure of science curriculum has the essential difference in curriculum structure. The remarkable characteristic of science curriculum is the integration, which is emphasized from curriculum structure system of science but by simple superposition of different subject knowledge.

Integration in the <Standard> is defined that “the integration in science curriculum should surpass subject boundary of separate science, remain core contents of science and pay attention to digest of knowledge, skills among different subjects firstly, should enhance scientific literacy of students, integrated science knowledge, skills, attitude, emotion, value, process, method and ability, infiltrate conception of interaction in science, technology and society secondly”. According to this thinking and referring to international curriculum structure of science, content structure in <Standard> is established by three of aspects, which are life sciences, material science, the earth, universe and space science. Science teachers graduated from separate science specialty can hardly master the structure in the first circle in integrated science teaching.

5.3 The change of curriculum factors

According the curriculum character, the integrated science curriculum is still belonged a subject. Curriculum factors in this subject sums up eight aspects which are basic concept, principle (including regulations), symbolism, measurement, skill, method, thought, emotion system. It has changed a lot comparing with the curriculums of separate science.

The knowledge system of a subject mainly consists of the basic fact, concept system and basic principle and curriculums of separate science have their own characteristic. Correspondingly, the biology emphasizes the facts, which become main content of the curriculum by induction and summary, physics emphasizes the abstract concept and the principle but facts, which are only shown as examples or application of concepts and principles. As for chemistry, it is situated between the biology and physics.

The curriculum factors of the science subject have changed a lot compared with those in separate sciences. This change of factors needs corresponding reformation of the teaching methods. The teachers in separate science subjects are only familiar with the teaching methods of their own subject, which results in the difficulties in teaching and absence of teachers self-confidence.

5.4 The change of thinking way in the curriculum

The research objects of physics, chemistry and biology are natural phenomena and laws, and the thinking mode in the curriculums is mainly logical. However, each subject has its own thinking way in the development.

Traditional teaching contents in physics, chemistry and biology have involved in relation of cause and effect in middle schools in China. In the curriculum of separate sciences, the method applied is basically the single factor analysis and most of theories studied by students have appeared as absolute truth, which is doubtless. But in curriculum of integrated science now, many new achievements of contemporary science and technology are accepted, not avoiding problems related to development of science and technology. Furthermore, some ability cultivated in inquiry study is emphasized, such as looking for and presenting questions, making hypothesis, designing inquiry programs, collecting evidences, analyzing and demonstrating, evaluating and communicating. However, because normal universities in China have not the corresponding curriculums, majority teachers teaching science curriculum in middle schools cannot understand the change, which is also one of reason for the teachers against the curriculum.

6 Considerations for Further Curriculum Reformation

6.1 Provide powerful support for the reformation

It is normal having some problems in the practice of the integrated science curriculum. The new curriculum has been put in practice in elementary and middle schools, which is an important decision-making discussed widely and thoroughly by hundreds of experts, based on investigation and research in China and in the world. This is an important decision and a significant action in this curriculum reformation of elementary education area. In order to enhance understanding the significance of integrate curriculum, teachers should change their ideas about education.

The problems appeared in implementing the integrate curriculum have related to many aspects, such as education ideas, administration and evaluation. In order to assure the development of the integrate curriculum, the educational administrative departments should take more care to practice areas and schools, have proper administrative measures and reliable policy, train the teachers, increase financial support. Especially science teachers should be offered support and encouragement, should be supported in the evaluation of professional titles, work load and post authorized.

6.2 Establish effective system for appraisal

The reformations of high school entrance examination should be linked up with the reformation of the integrate curriculum. It is an urgent task to set up a rational and effective appraisal system for integrate curriculum. The standards for the curriculum of separate sciences are not those for the integrated science. In some schools the students taking the integrate curriculum are tested by the examination papers for separate sciences, by which the teaching will be misled. The teachers will face huge challenges in the aspects of educational idea, knowledge structure, experiment skill and teaching behavior when they offer the integrate course. In the practice process, it is necessary to make appraisal criterion for the teachers in time in order to lead and standardize the teacher's teaching effectively.

6.3 Strengthen the professional support

It is necessary to strengthen the professional support to the integrated science curriculum. Actually, the training of the teachers is the method meeting the emergency. For the long term, we need the long-range plans and efficient measures. In normal universities and colleges, there should have the specialty, integrate curriculum for integrated science and train the students as high-quality teachers for integrated science.

In fact, the curriculum structure of some universities or colleges has already adjusted with the curriculum reformation development. For instance, some normal universities and colleges have set up the specialty of integrated science education.

Table 5, List of specialty of integrated science in universities or colleges authorized by the Ministry of Education (46, 2001-2004)

Universities (colleges)	Authorized by the MOE	Specialty	Studying years	Degree
Chongqing Normal University	2001	Science Education	Four years	Science
Zhangzhou Normal College	2002	Science Education	Four years	Pedagogy
Jiangxi Normal University	2002	Science Education	Four years	Pedagogy
Huaihua College (Hunan)	2002	Science Education	Four years	Pedagogy
Guangxi Normal University	2002	Science Education	Four years	Pedagogy
Southwest Normal University	2002	Science Education	Four years	Pedagogy
Shaanxi Normal University	2002	Science Education	Four years	Pedagogy
Northwest Normal University	2002	Science Education	Four years	Pedagogy
Zunyi College	2002	Science Education	Four years	Pedagogy
Guizhou Normal University	2003	Science Education	Four years	Pedagogy
Qiannan Nationality Normal College	2003	Science Education	Four years	Pedagogy
Sichuan Normal University	2003	Science Education	Four years	Pedagogy
Taiyuan Normal College	2003	Science Education	Four years	Science
Xihua Normal University	2003	Science Education	Four years	Pedagogy
Qinghai Normal University	2003	Science Education	Four years	Pedagogy
Tianshui Normal College	2003	Science Education	Four years	Science
Yunnan Normal University	2003	Science Education	Four years	Pedagogy
Guangxi Normal College	2003	Science Education	Four years	Science
Yulin Normal College	2003	Science Education	Four years	Science
South China Normal University	2003	Science Education	Four years	Science
Zhanjiang Normal College	2003	Science Education	Four years	Pedagogy
Xu Chang College	2003	Science Education	Four years	Pedagogy
Yantai Normal College	2003	Science Education	Four years	Pedagogy

Gannan Normal College	2003	Science Education	Four years	Pedagogy
Shanghai Normal University	2003	Science Education	Four years	Pedagogy
Zhejiang Normal University	2003	Science Education	Four years	Science
Shaoxing Human and Science College	2003	Science Education	Four years	Science
Ningbo University	2003	Science Education	Four years	Science
Shenyang Normal University	2003	Science Education	Four years	Pedagogy
Shanxi Normal University	2003	Science Education	Four years	Science
Bohai University	2003	Science Education	Four years	Science
Changchun Normal College	2003	Science Education	Four years	Pedagogy
(Xinjiang) Changji College	2003	Science Education	Four years	Pedagogy
Hebei normal University	2004	Science Education	Four years	Science
Huihua College, Hebei Normal University	2004	Science Education	Four years	Science
Yuncheng College	2004	Science Education	Four years	Science
Harbin Normal University	2004	Science Education	Four years	Science
Hangzhou Normal College	2004	Science Education	Four years	Science
Huzhou Normal College(Zhejiang)	2004	Science Education	Four years	Science
Taizhou College(Zhejiang)	2004	Science Education	Four years	Science
Xiangfan College(Hubei)	2004	Science Education	Four years	Science
Xiaogan College (Hubei)	2004	Science Education	Four years	Science
Yuxi College (Chongqing)	2004	Science Education	Four years	Science
Leshan Normal College	2004	Science Education	Four years	Science
Guiyang College	2004	Science Education	Four years	Science
Hexi College (Gansu)	2004	Science Education	Four years	Science