HUANG XIAO & MAO CHANGYUN

10. THE INTEGRATED SCIENCE CURRICULUM IN MAINLAND CHINA

The development of the integrated science course follows the history track of international science curriculum development. Although the integrated (comprehensive) science course is regarded as an undisputable fact in all countries, it presents different characteristics and implementation degree in courses because each country pays differing attention to integrated science curriculum owing to different teaching resources, instruction content, and teaching methods, among others. From the 1980s, the integrated science curriculum reform in China started from high school attached to Northeast Normal University, and then parts of schools in Shanghai carried on science course experiment. At the end of the 1980s, Zhejiang province started the integrated science curriculum reform. With the national eighth-time curriculum reform of 2001, integrated science curriculum has already formally become important part of national education course system. Science curriculum standards of compulsory education, which are the bases of science curriculum implementation, were compiled. However, the implementation of integrated science curriculum did not receive extensive favor in the reform. Against 38 national experimental areas in 27 provinces (e.g., the autonomous region, direct jurisdiction city) under the reform, only 7 regions chose the integrated curriculum. Only two million students have used the science curriculum consistently until 2006, after which several experimental schools withdrew from its implementation. Because of the withdrawal of the science course in Wuhan City, Hubei, in 2009, how to make the integrated science experiment successful in practice became the focus of attention. The integrated curriculum reform of Zhejiang in the last 20 years has become the example of an integrated science curriculum. Thus, its study can not only provide data regarding its successful implementation of the program, but also shed light into how to adapt implementation of the program to other areas and make nationwide implementation possible.

INTRODUCTION

Integrated Science

Although science curriculum is more widely known as an integrated curriculum, it holds different titles and designs in different times and different regions, such as "Science," "Nature," "Natural Science," and "the Physical Sciences." No matter the title, integrated science curriculum is a comprehensive curriculum form designed

E.H.F. Law and C. Li (Eds.), Curriculum Innovations in Changing Societies, 189–215.

to span the physical, chemical, biological, and geographical fields. The content of integrated science curriculum is systematically selected and organized, which helps to break the boundaries between disciplines.

Beginning with the new curriculum reform and compilation of science curriculum standards, integrated science curriculum has become an important part of national basic education curriculum. The study of integrated science covers a wide range of concerns, including the publications related to integrated science curriculum, such as "Science Curriculum,"(Yu, 2002) "From the Traditional to the Modern: The Development of Integrated Science Curriculum," (Guo, 2002) "Paradigm Development of Science Curriculum," (Zhou, 2010) and "Integrated Science Curriculum Design." (Yu, 2011) In addition, several doctoral theses, such as "From Division to Comprehension: On Science Curriculum Setting," (Pan, 2004) "Culture Interpretation and Construction of Science Curriculum," (Yu, 2003) and "Content Integration of Mainland Integrated Science Curriculum," (Sun, 2010) all theoretically explain the problems of science curriculum, such as its features and its implementation, as well as the setting and the ideal design.

Implementation of Science Curriculum

Fullan (1991) proposes that curriculum implementation is the process of putting the reform into practice, which concerns the extent and factors of real reform. Thus, the implementation of science curriculum reform in science curriculum is the most prominent and most difficult issue to resolve in curriculum reform, and is main measure of whether the science curriculum reform is a success. As to the implementation of integrated science, some researchers and science teachers have conducted a study to explore its theory and practice, such as methods of organization, strategies of implementation, and academic assessment. However, these studies are not systematic; thus, the regional and empirical study of integrated science curriculum and its implementation cannot be summarized to guide the effective implementation of the integrated science curriculum in other provinces.

RESEARCH DESIGN – CONTENT AND METHOD

Research Questions

Our main research goal is to determine the implementation status of integrated science in Zhejiang. To achieve this goal, we decompose our issue into a series of questions:

- How did the integrated science curriculum of Zhejiang province develop? Is it similar to the process experienced in other provinces?
- How were we able to implement that integrated science curriculum when other provinces (such as Wuhan) have been forced to revert to the subdivided curriculum?

- How was the integrated science curriculum carried out currently in Zhejiang? Is there are any worthy of success and experience for other provinces to follow?
- What are the issues encountered during the implementation of the integrated science curriculum? What are the effects of these issues on the implementation?

This study attempts to answer the above questions by analyzing the related literature, and performing surveys and in-depth interviews. It contains three steps:

First, we will review the history of science curriculum in the mainland by showing the process of "the natural science" experiment, by following the change from "the natural science" to "science" curriculum, and by analyzing the related literature, combined with the interviews of seal reformers.

Second, we will compile Likert questionnaires on the implementation of the integrated science curriculum. Some science teachers will be asked to complete the questionnaire, and their answers will be analyzed using frequency statistical analysis. Because the science curriculum attempts to promote the scientific literacy of students and because the nature of science is the core meaning of science literacy, we will further develop a Likert questionnaire survey for science teachers to study their understanding the nature of science.

Finally, based on "comprehensive, independent, cooperation, exploration, and difference," as advocated by the science curriculum standards, we consider integrated science curriculum construction from several viewpoints: the nature of subject and its teaching, reform and innovation of pedagogical content, internal mechanism, and characteristics of learning, instruction design that embodies students' development, teaching strategies, and effective teaching evaluation. We will design an interview outline following four progressive dimensions: awareness, understanding and application, and self-reflection. Several science teachers from different cities and areas will be interviewed and several teaching videos will be taken for classroom observation to further analyze the pros and cons of implementation in order to determine the current state and effectiveness of the integrated science curriculum.

Instruments

In this study, we use questionnaire of "the status quo of integrated science curriculum implement,"and "understanding of the nature of science," which we compiled ourselves. Multi-dimensional and multi-level interviews are conducted, and several classroom-teaching videos are taken. As to the questionnaires compiled, we not only consult the relevant literature regarding the integrated science curriculum implementation and the nature of science locally and abroad, but also consider the continental characteristics of science curriculum reform. The interview outline comprises three levels and seven parts. The videos taken contain science classroom teaching for public and the regular classroom teaching as well.

Methods

In this study, we used questionnaires, interviews, and classroom observations, as well as the extant literature, to understand the status of the integrated science curriculum and its related issues.

Literature. We consulted science curriculum reform documents nationwide and from Zhejiang Province, including research reports and documents on the science curriculum reform and its implementation.

Questionnaires. We handed out approximately 500 questionnaires among science teachers of different areas and cities (such as Ningbo, Shaoxing, Hangzhou, Jiaxing, and Wenzhou) in Zhejiang, as well as 200 science teachers from Yuhuan of Taizhou and Jinhua. After receiving the filled-out questionnaires, we used SPSS 16.0 for statistical analysis.

Interviews. We used the "one-to-many" form to interview approximately 100 science teachers in four main regions: Wenzhou Lucheng, Wuyi, Shaoxing, and Hangzhou Bingjiang. The content mainly paid attention to the attitudes of these science teachers to the science curriculum reform and the problems and difficulties of its implementation.

Classroom observation. By means of video recording, we used the observation scale of Cui for classroom observation and analysis in order to understand the bright spots and shortcomings of science teaching, specifically with regards to scientific inquiry, cooperative learning, and scientific experiments in science teaching practice.

Objects

1. We mainly took science teachers as our investigation objects, combined with text analysis and classroom teaching to determine the understanding of science teachers of scientific literacy and the nature of science, which crucial for science curriculum implementation.
2. As to the sampling of investigation object, we considered economy and the culture differences among the cities. In addition to stressing the samples from different cities of Zhejiang Province, we lay particular emphasis on a comparison of the two areas.

THE HISTORICAL EVOLUTION OF THE SCIENCE CURRICULUM

The purpose of integrated science curriculum in our country is based on the criticism of the subdivided curriculum. In other words, the integrated curriculum and the subdivision of courses are regarded as opposing sides, which not only denies the existence of the reasonableness of the subdivision of courses, but also destroys the relationship between integrated science curriculum and the subdivision of courses. For examples, regardless of high school integrated science curriculum reform attached to Northeast Normal University or the reform and practice from "natural science" to science in Zhejiang Province, integrated science courses are considered the opposition side, rather than as a continuous reform of the subdivision of courses (such as into physics, chemistry, biology, etc.). "Ingram,1985", the current integrated science curriculum, which has gone from "natural science" courses to the science curriculum and then incorporated into the national science curriculum, has mainly been implemented only in Zhejiang Province.

"National Science" Curriculum Reform in Zhejiang

After the high school attached to Northeast Normal University and Shanghai Education Bureau, Teaching Research Office carried out the first small-scale integrated junior high school science curriculum experiment in 1980s. Research and development of science integrated science curriculum have been carried out in Zhejiang in response to the policies of national basic education. Specifically, the process of "Natural Science" curriculum reform is based on the following:

1. Investigation and analysis of the development of international science curriculum. According to Hongjia Wang's book "New Education Crisis of China," some researchers went to Hong Kong for their integrated "science" curriculum and its variety of textbooks, whereas other researchers went to Taiwan and the United Kingdom and other countries to conduct research and analysis.
2. Reflection of the problems from the subdivision of courses (physics, chemistry, and biology). For instance, no study has been conducted regarding the what and how of teaching in the junior high school science curriculum, such as whether the scientific content is too difficult for compulsory education students to learn, possibly resulting in a high rate of dropouts, and whether students can be cultivated to meet the requirement of social, technological, and economic development.

"Natural Science" Curriculum Reform Process

As to the development of integrated science curriculum, the Education Commission of compulsory education with the Teaching and Research Section used competition-motivation method to determine its main design. On November 29, 1989, the chief editor, sub-editors, and other members for science textbook development were chosen. Ziqiang Yu was chosen to be the chief editor, Xingxin Yan and Yiping Zhu were chosen to be the as sub-editors (later Shangen Yu in place of Yiping Zhu), and the members comprised Yiquan Cheng, Xiaozheng Chen, Wenqing Wu, Hongfeng Fang, and so on.

The development process of "Natural Science" was not only to absorb the experience and lessons of reform in the high school attached to Northeast Normal University, but also included in-depth analysis and research on the characteristics of international integrated science curriculum, especially the integrated science of Britain, Hong Kong, Taiwan, Japan, and so on. Combined with philosophy and practice, the development of science textbooks was based on an analysis of national standards (outline) and teaching materials, study and analysis of curriculum objectives, structure, content, organization, degree of comprehensive, and so on. According to the investigation of science teachers of Zhejiang Province, two-thirds are young teachers; therefore, the government decided to begin implementation here because of their high adaptability.

In September 1991, three experiment areas, namely, Guancheng in Cixi, Keqiao in Shaoxing, and Zhuji carried out the integrated science curriculum reform recognized by the leaders of state educational committee. Five thousand Grade One junior school students were involved in the experiment.

In February 1992, the experiment was expanded to 24 counties (including Xiaoshan, Longyou, and Qingyuan). Approximately 40,000 Grade One junior school students were involved in the experiment. We built “the instructional plan of compulsory education,” which reduced primary subjects from 11 to 8, decreasing the total hours from 5,100 to 4,760, and reduced the required subjects in junior high school from 14 to 12, decreasing the total hours from 3,066 to 2,648. Approximately 388 elective subjects, activities, and social practices were added.

When implementation of “Natural Science” was attempted in the whole province, it suffered opposition from secondary school teachers, principals, university teachers, and academicians. These parties submitted proposals to National People’s Congress (NPC) and Committee of the Chinese People’s Political Consultative Conference (CPPCC) through letters and petitions, applying great pressure for the implementation of integrated science curriculum. According to Zhongjie Shao, the editor of Education Commission, “…I can own nothing, but the reform of integrated curriculum cannot give up.” The integrated curriculum thus was persisted in.

Because the experiment was expanded to the whole province in 1993, whether the science teachers were suited to the comprehensive of “Natural Science” textbook was considered. In 1994, the comprehensive degree of textbook was reduced to maintain the direction of integrated science curriculum.

In 1995, academicians and educators put forward their different views about the integrated science curriculum. Fortunately, the integrated science curriculum was supported by Zhichun Xu, the vice governor of Zhejiang Province. Bing Liu correctly set the direction of integrated science curriculum, which enabled the integrated curriculum in Zhejiang to survive.

In February 1998, the seminar on “Integrated Curriculum of Basic Education” was jointly held in Hangzhou by former Basic Education Department of State Education Commission and Zhejiang Province Education Commission. Experts from eight universities and educational institutions (such as People’s Education Press, North China Normal University) attended and expressed high regard for the integrated science curriculum reform. The important reform achievement was also reported by CCTV News Broadcasting.

"Natural Science" Curriculum and Teaching Materials

The design of any kind of curriculum should be based on knowledge, the students, and society. The integrated science curriculum in the junior high school of Zhejiang Province is also based on certain social background, science and technology development, and students' learning. The content selection of "Natural Science" considers three aspects: improving peoples' science literacy via the integrated STS curriculum, scientific methods training, and patriotism. Thus, the content of science curriculum includes biology (approximately 30%), physics (approximately 25%), chemistry (approximately 20%), geography (approximately 10%) and integrated topics (approximately 10%). Its features are embodied in the following contents:

1. Energy conversion and conservation, mass conservation, biological evolution, ecological balance and other basic principles and laws of nature;
2. Plants, animals, micro organisms, humans, the earth, molecules and atoms, elements and their compounds, physical movement and chemical reactions, and organisms and environments;
3. Training of scientific methods, such as observation, experiment, investigation, logical reasoning, exploration, and so on; and
4. Scientific achievements and scientists.

As to the curriculum structure, different ways to organize exist, such as the integrated science curriculum centered on concepts, scientific research methods and process, science topics, life experience, and social issues and so on (Fan, 1998). Considering that the theme-centered style cannot be adapted to China's actual conditions, we adopted the "step-by-step placement strategy" (Yan, 1991) to organize "Natural Science" curriculum. Using this strategy, the content of curriculum falls into three parts within six volumes. "Understanding the nature," the first part, includes the richness and color of nature (the nature around us, observation and measurement, animals, plants, and the earth). Volumes II, III, and IV belong to the second part, "exploring nature, which covers the (1) physics and life, which consists of physical characteristics and the basic units of life, and covers plant nutrition, exercise and senses, the history and continuation of life; (2) material and movement, which consist of the composition and changes of material electromagnetic motion, body's motion and metabolism, regulation of human activities; and (3) matter and energy, which are composed of force, power and mechanical energy, thermal and chemical energy, and electrical energy. The third part is "the relationship between human and nature," which includes ionic solutions, raw materials, and the environment and its protection.

One characteristic embodied in "Natural Science" content its focus on inquiry learning through three steps: (1) design a number of exploratory experiments and practice, such as campus observation and practice in Volume I, observation and collection of protozoa and algae in Volume II, installation of a door bell in Volume III, and investigation of the population growth and environmental conditions in Volume

VI; (2) provide an open forum for discussion, such as the topics of "biotic and abiotic" and "the evolution of nervous system; and (3) design a variety of scientific exploration activities for one topic, such as design four scientific inquiry activities(Is there starch in soil? Leaves without ultraviolet ray? Green leaves with light? What condition does photosynthesis produce?) for photosynthesis in Volume II.

Another characteristic of the "Natural Science" curriculum development is the introduction of STS curriculum, which is specifically related to five aspects: (Yu,1996) (1) the relationship between science and technology, covering technologies and technical achievement when introducing scientific facts, concepts and principles; (2) science, technology and social issues seminars on population, energy, resources, ecology, and the environment; (3) the personals trait and social responsibilities of scientists, which introduces ten Chinese scientists (Shizheng Li, Xuesheng Qian, Yingxing Song, Longping Yuan, and so on) and six foreign scientists and their achievements and role in economy, culture, and society; (4) the social nature of science, wherein we attempt to summarize science knowledge from historical and social point of view; and (5) the characteristics of science, which focus on the scientific method, attitude and spirit, topics of observation, analogy, classification, scientific experiments, mathematical methods, and so on. In addition, "Nature Science" strives to guide students to participate and explore practical issues to understand how science research is conducted.

Teachers' Professional Development in "Natural Science" Curriculum Reform

The success of any curriculum reform is inseparable from the professional development of teachers and the "Natural Science" curriculum reform as well. Since the three experiment areas started the reform in September 1991, the Working Groups of Natural Science frequently went to experimental areas for specific guidance to determine whether science teachers could adapt to integrated science teaching. They suggested science teachers should attend one-month specific training courses. The teachers would not only learn educational theory and become familiar with the materials and teaching guidelines, but also gain in-depth understanding of the intention, structure, and system of the science textbooks. A series of measures were adopted, which are as follows:

1. The integrated science teaching and research group was composed of teachers of physics, chemistry, and biology. School-, township-, and district-level science education research networks were formed to facilitate discussion and conduct research activities.
2. Science teachers were recruited and categorized by their academic background (biology for Grade One, physics for Grade Two, and chemistry for Grade three) and research experience.
3. Collaborative preparation for classes were held every Friday, which all science teachers should attend to discuss the research activities of integrated science in order to prepare for the next week's science teaching.

As to the difficulties from science teachers, two effective measures were adopted. On one side, the content and degree of integration was adjusted, and variety of teaching organization was extended. On the other side, strategies to promote science teacher adaption were put forward, such as the establishment of teaching and research groups are collaborative preparation and the need for full-time integrated science teachers. The science teachers aged under 35 were required to teach "Natural Science" independently. Additional laboratory equipment was needed, as well as full-time laboratory assistants. In addition, science teachers were asked to improve their implementation capacity by attending teaching methods, research, and other various types of training, such as group discussions.

From "Natural Science" to "Science"

A large-scale survey on curriculum implementation of compulsory education was carried out by Basic Education Department of Ministry of Education in 1996. The survey covered the achievement of the curriculum objectives, suitability content, evaluation issues, and so on. The subjects for this investigation were students, teachers, and principals. An investigation report was submitted at the end of 1997. In January 1999, experts from the working group of Basic Education Curriculum Reform, after more than 100 seminars, "released the outline of Basic Education Curriculum Reform (Trial),"signalling the new start of basic education curriculum reform that was formally promulgated in June 2001. It put forward the combination of the subdivided curriculum and integrated curriculum for junior high school, and actively initiated the choosing of the integrated curriculum. In April 2000, "Science (Grades 7–9) Curriculum Standards (trial version)," which emphasized that "for all students, based on the students development, embody the nature of science, stress scientific inquiry, and reflect contemporary scientific achievements" and aimed to enhance all students' scientific literacy, was launched. According to this document, scientific inquiry and relation of science, technology, and society are most crucial content, as well as physics, life sciences, and aeronautical sciences. Four textbooks were compiled based on the curriculum standards. In the autumn of 2001, science curriculum was initiated in 38 experiment areas in 27 provinces (autonomous regions and municipalities) Nanshan in Shenzhen, Kaifu in Changsham, Lingwu in Ningxia, Quwo in Shanxi, Wuhai in Inner Mongolia, Jinzhou in Dalian, and Gaomi of Shandong were among the first science curriculum experiment areas (later on, Gaomi in Shandong and Jingzhou in Dalian withdrew from the experiment). Zhejiang conducted the experiment in batches; three experiment areas in 2002, the number of 52 in 2003, and the whole province in 2004, "Natural Science" curriculum ended its historical mission and was replaced by the "Science" curriculum.

1. Development and revision of science textbooks based on science curriculum standards. Two kinds of science textbooks exist: one version is published by the East China Normal University Publishing House, whereas the other version is published by Zhejiang Educational Publishing House, which further developed the "Natural Science" textbook used by most areas of Zhejiang Province. The "Science" textbooks are based on "Science Curriculum Standards" and take "the Existing Nature–the Evolution Nature–Nature and Humanity" as clues to comply, shifting from a static to a dynamic nature, and focusing on fundamental issues, namely, the relationship between human beings and nature. Based on "material, movement, energy, information, systems, structure, evolution, balance, conservation" unified concepts and principles, seven topics (the level of material systems, movement and change, interaction, structure and function, transformation and balance, evolution, development and harmony) are established in the science textbooks. According to the editors, the "Science" textbooks strive to embody two characteristics: (Fang, 2006) (1) discipline based on the utility of knowledge, process, and culture and (2) discipline based on the utility of nature of science and nature of education with an emphasis on students' thinking and their cultural background, stressing on the students' experiences to determine their understanding of the nature of science).

Professional development of science teachers. The "Science" curriculum emphasized the scientific inquiry theme and STS topics, which put forward the new requirements of inquiry, problem-solving, and application abilities for science teachers. Specifically, for the topics of "science, technology, and society" and "the earth, the universe and space science," not only did different disciplines of knowledge need to be integrated, but teachers also had to go beyond the boundaries of their discipline, needing the facility to connect different disciplines of knowledge and skills to enable students to understand the relationship of science, technology and society, and then enhance their understanding of the nature of science and scientific literacy. The interdisciplinary and integrated nature of the "Science" curriculum required science teachers to own a broader academic background and wider adaptation skills, which also affected the science education major of normal universities.

Science teachers are mainly physics, chemistry, or biology majors; thus, many were unable to adapt to the implementation of science curriculum. Fortunately, the problem was gradually solved with the attendance of Universities of Zhejiang Province during the new round of science curriculum reform. As to cultivation of science teacher, we should refer to the major of science education created by Zhejiang Normal University, Ningbo University, and Shanxing College in 2003. Hangzhou Normal University, HuZhou Normal College, and Taizhou College also established this major in 2004. Science education refers to the training of science teachers, comprising a variety of training programs (such as leadership project or provincial/municipal training) for the professional development of science teachers.

STATUS QUO AND REFLECTION OF SCIECNE CURRICULUM IN ZHEJIANG

The integrated science curriculum of Zhejiang, from "Natural Science" to "Science," is nearly two decades old; however, systematic evaluation of the scientific literacy of students has not been conducted. The investigation of students' scientific literacy, covering the basic understanding of scientific and technical terms and concepts, scientific research and its methods and impact of science on society, was conducted in 1997. The survey results showed no significant difference of students' scientific literacy between experimental areas and non-experiment areas of "Natural Science."In short, the students' understanding of scientific literacy was not weakened because of the implementation of "Natural Science" with the science teachers who could not adjust to integrated science teaching.

Several surveys were carried out after the new "science" curriculum implemented after 2002. One survey, "Investigation and Analysis Of Science Curriculum Implementation for the Junior High School of Wen Zhou" was conducted by the Wen Zhou Research Institute in October 2004 (Lin, 2004). The results showed that the feature "Science" curriculum can be distinguished from "Natural Science" by the "students' autonomy" emphasized in the instructional design, but also by the classroom behavior and research of science teachers. Another survey done in September 2006 investigated a third-year graduate students' scientific literacy. (Zhang, 2007) The research results showed that the students' scientific literacy, embodied in the students' understanding of problem-solving methods, scientific attitude and values, and the relationship of science, technology, and society, were significantly different among students from the experiment areas and those from the non-experiment areas.

"Shall we go on integrated science curriculum?" is no longer a controversial question for the science curriculum reform of Zhejiang; however, other provinces continue to discuss this problem. We should explore how we can carry the integrated science curriculum reform a step forward. We should face the status of our science curriculum implementation and analyse the problems that confront us. To clarify problems in the practice of integrated science curriculum implementation for two decades, we gathered data regarding the status of integrated science curriculum implementation from more than 500 science teachers in different regions. The research tool includes questions for interview, videos and questionnaires which are compiled and revised based on test measurements.

Indicator Construction

The concept of "Curriculum Implementation" must be understood in order to construct indicators of implementation of science curriculum in Zhejiang. For curriculum implementation, different scholars have proposed a multi-dimensional understanding, which means many issues are involved in curriculum implementation. However, regardless of type, no curriculum implementation can occur without teachers and students. Thus, we built indicators in view of the five dimensions understanding of curriculum implementation proposed by Fullan and Pomfret (1977), especially the subject in the curriculum implementation and its relation. Thus, the investigation for science curriculum implementation consists of 34 questions, which includes

Table 1. Indicators of science curriculum implemenatation

First-grade index	*Second-grade index*	*Third-grade index*
System of Science Curriculum	Nature of subject	Understanding the integration and logic of science curriculum
		Distinguishing science curriculum and the subdivided courses
	Existing curriculum form	Curriculum form must be multi-disciplinary in nature
		Existing curriculum form of every school
Science Teachers	Professional background and degree of adaptation	Professional background
		Ability to adapt to integration
		Teachers' adaption to the new content and teaching methods
	Teacher communication and training	Form and demands of communication of science teachers
		Science teachers' training needs, opportunities, and effects
Science Textbook and Curriculum Content	Science textbook	Whether science textbook reflects the nature of science
		The difficulty of scientific content, the logic of the layout
		Synthesis of science textbook
	Science experiment	Science laboratory, equipment, and assistant
		Scientific experiments skills of science teachers
		Scientific experiments carried out
	Other curriculum content (such as nature of science, history and philosophy of science, STS education)	Attention paid to other curriculum content
		Instruction and analysis for other science contents
Teaching Style and Methods	Scientific experiment	Scientific experiment instruction
		Instruction of science experiment
	Other teaching methods	Variety of learning styles (such as inquiry learning, cooperative learning, etc.) to carry out

four first-grade indices, nine second-grade indices, and twenty third-grade indices (Table 1). As to the questionnaire of understanding the nature of science, we built indicators according to McComas' views of international science education. The first-grade indices (Table 2) cover the nature of scientific knowledge, the nature of scientific inquiry, and the nature of scientific cause. In addition, the interview outline is based on the nature of science curriculum and science curriculum standards,

Table 2. Indicators of the nature of science

Nature of scientific knowledge	*Nature of scientific inquiry*	*Nature of scientific enterprise*
Durable of tentative character, replicability, creative, evolutionary, and revolutionary	Skepticism, challenge empirical data, logical reasoning, limitation, methods of diversification, theory-laden, lack of no universal step-by-step scientific method	Cultures contribute to science; scientific ideas are affected by their social and historical milieu

Table 3. Design ideas for interviews on science curriculum implementation

Awareness	Integrated science curriculum construction	Characteristics different from subdivided courses, such as the proportion of theory, experiment and practice, and the degree of integration
Understanding and Application	The nature of Science and its teaching	Connotation and its teaching of the nature of science, science teaching objectives and its embodiment, and nature of subject and its teaching
Reflection	Pedagogical content, reform, and innovation	Science textbook and other curriculum resources, the content and chosen basis of science experiment content, and the proportion of various types of science experiments

especially on the understanding of "comprehensive, independent, cooperation, inquiry, and difference." We designed it from seven dimensions based on three levels (Table 3).

Indicators Construction

Based on the index construction, we chose science teachers from four different districts of Zhejiang Province to survey. We interviewed them regarding the construction of integrated science curriculum, the nature of science and science curriculum objectives, implementation and reform of science curriculum content, science learning mechanisms and processes, science curriculum implementation strategy and evaluation, the professional development of science teachers, and the environment of science education. We conducted in-depth analysis of integrated science class records (heterogeneous classes, open classes, etc.). Because of the importance of the nature of science for scientific literacy, we specifically surveyed the science teachers' understanding of the nature of science.

Positioning of integrated science curriculum form. We can classify comprehensive curriculum by the existence curriculum form and its core. The integrated curriculum is divided into systematic integrated curriculum (also known as wide-area courses, which organize a field of subjects to cover the entire curriculum), such as the problem-centered integrated curriculum; human-centered integrated courses (general education in Hong Kong); the integrated curriculum combining two or more disciplines (stressing the breakdown of various disciplines of knowledge system to form new knowledge system); and modular integrated courses (two or more related disciplines maintaining relatively independent subjects in the topics or ideas). (Li, 2006) Integrated science curriculum is an ideal course manifestation, which is essential in the achievement of students' scientific literacy. Therefore, the coexistence of a variety of courses is necessary, and subdivided courses can be combined with an integrated curriculum in the current national basic education system. However, two forms exist in our current science curriculum implementation process. First, "Combined Science" (physics+geo graphy,biology+chemistry) exists in Riverside District, which regarded as the kind of intermediate state for integrated science chosen under the existing textbooks system, evaluation system, and teacher professionalism. When we focus on the reasons for "combined science" teaching, some science teachers believe it to be a form adapted to the needs of the current evaluation, which shows knowledge of the subdivided courses in a combined test. Some science teachers believe that "combined science" helps students build an in-depth understanding of scientific knowledge and develop systematic thinking. Of course, "combining science" is partly based on science teachers' professional sources (sub-division development). Second, the "integrated science" form, with integration of physics, chemistry, biology, and geography into one, which is present in Lucheng District, is the ideal form of "Natural Science."

Nature of science and science curriculum objectives. The students' understanding of scientific literacy is the ultimate goal of science curriculum. Understanding the nature of science is the core meaning of scientific literacy; therefore, the objective of science curriculum is to promote students' understanding of what science is, as reflected in the specific science curriculum design, content compliance, implementation, and evaluation. Therefore, explaining the meaning of scientific literacy and the nature of science is necessary. Science teaching should distinguish between science and pseudo-science, subjectivity and objectivity, observation and conjecture using variety of scientific methods.

In the survey of science teachers, most science teachers recognized promoting students' understanding science literacy as the object of science curriculum and teaching; however, they lacked accurate and comprehensive understanding of the content of scientific literacy. Because of the evaluation, teaching materials and other factors, knowledge and skills are paid much attention in science teaching, whereas "process and approach," "feelings, attitudes and values" are often kept outside of science classroom. As to the nature of science, most science teachers focus on "logical," "experimental," and "useful (practical)" in the implementation of science curriculum. Thus, the understanding of science teachers of the nature of science is preliminary and fragmented, and they cannot accurately understand the rich and dynamic content, such as temporary, openness, reproducibility, empirical verifiability, and subjectivity (scientific knowledge based on human imagination and creativity) of scientific knowledge.

Science teachers generally think "science–technology–society" should be emphasized and embodied in science teaching to improve the interest of students in science and their understanding of the significance of learning science. Such lessons can also be interspersed with some of the examples into science teaching, such as the application of science and technology in the real life. However, most science teachers are not able to examine science teaching according to STS; they merely add technical and social elements to improve students' interest in learning science, not to help them understand science based on its relation with technology and society.

A tool to measure the understanding the nature of science of science teachers is needed. We not only compiled a questionnaire, but also used scientific observation to test the understanding the nature of science of science teachers. We used SPSS for effective system to obtain the value of **α** (0.746), which satisfies the "internal consistency" standard proposed by Nunnally in 1978. In short, the validity of the questionnaire is good if the value of **α** greater than 0.7.

1. Existing understanding the nature of science. As to the survey of science teachers' view of NOS, we designed questionnaires and carried out the investigation according to the essence index of NOS from six facts: "the relativity of scientific knowledge," "the subjectivity and objectivity of science," "the practice and creativity of scientific process," "scientific theory and scientific laws," and "relationship of science, technology, society and culture." The results are shown below (Figure 1a, Figure 1b, Figure 1c, Figure 1d, Figure 1e, Figure 1f).

As to the statistical analysis of "relativity of scientific knowledge, although 94.6 % of science teachers denied the invariance of scientific theory in Question 32, the results of Questions 1 and 18 presented approximately the same ratio of supporting and opposing viewpoints (57.4 ratio 39.1 for Question 1, 53.9 ratio 36.7

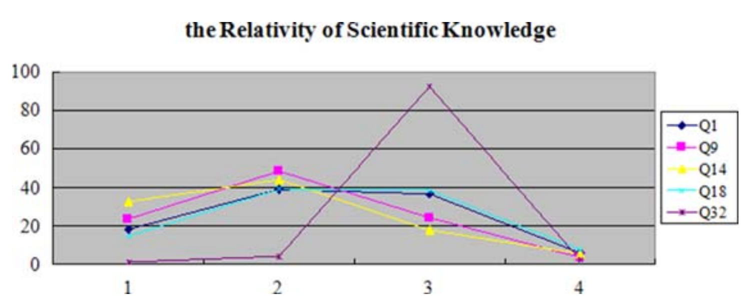

Figure 1a. The relativity of scientific knowledge.

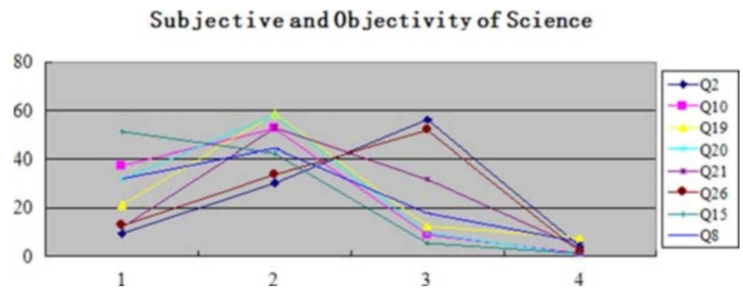

Figure 1b. Subjective and objectivity of science.

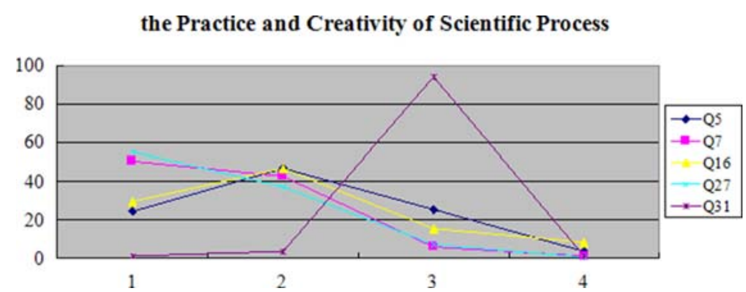

Figure 1c. The practice and creativity of scientific process.

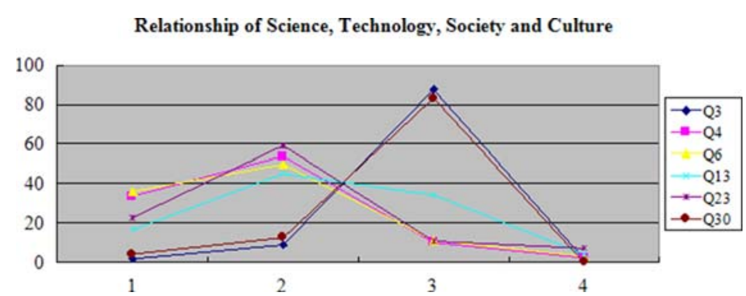

Figure 1d. Relationship of science, technology, society and culture.

for Question 18). For "scientific knowledge cannot be regarded as truth,"72.2 % of science teachers held a positive view; however, 24.5% of the science teachers did not agree. "Subjectivity and objectivity of science" was reflected in Question 8, with a ratio of 56.2 for support and 39.4 for opposition. We can deduce from Questions 10, 15 and 20 that most science teachers (89.9%, 93.5%, 89.8%, respectively) think

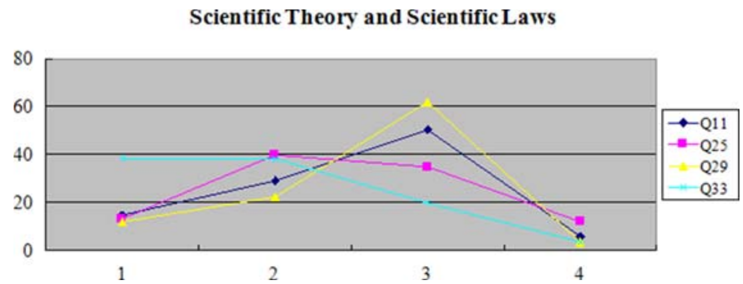

Figure 1e. Scientific tehory and scientific laws.

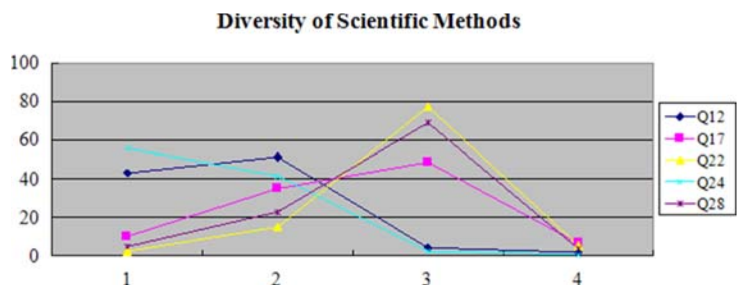

Figure 1f. Diversity of scientific methods.

scientists observing phenomena will be affected by their original theory and the observation purpose; therefore, different points of view, evidence, and interpretation for the same results will occur. However, the analysis of Question19, which shows 79.9% science teachers believe that scientists are objective in their data collection, is contradictory to the previous point of view. According to the answers given for Question21, although 64.7% of science teachers believe various activities will affect their research work and scientific conclusion, whereas 31.7% of science teachers did not agree with this view. Specifically, for the question regarding "scientific research seeks for the answer of objective facts and truth independent of the society and culture, respectively 46.4% and 51.8% of the endorsement and opposition. As to "practicality and creativity of the scientific process, science teachers pay more attention to imagination and creativity than to intuition in their scientific research.

We can deduce from the survey data that science teachers found "scientific theory and scientific law"the most difficult to understand. Although most science teachers have an understanding of scientific theory and scientific law, they seem unable to differentiate the two (the proportion of opposing and supporting viewpoints are the same, namely, the ratio of 43.8 to 50.3 for Question 11 and 53.1 to 34.9 for Question 25). "Understanding the relationship of science, culture, and society" is one aspect for science teachers found easy to understand, more than 80 percent of science teachers showed a clear understanding. As for "the diversity of scientific method, more than 90 percent of the respondents recognized the importance of curiosity and collected evidence in scientific research, but at different levels. Overall, science teachers seemed to have a different focus on understanding the different levels of the nature of science, but lacked a conception of modern science.

2) Understanding the status quo of science curriculum. In addition to the understanding of the nature of science of the survey implementers, we also need a clear picture of science teachers' understanding of the science curriculum (embodied in part in the problems in "the survey of science curriculum implementation"), which mainly reflect in the analysis of "the nature of science curriculum,"such as integration and logic of science curriculum (Figure 2). Approximately 75 percent science teachers regard the science curriculum as other subjects put together, 39.9 percent of science teachers think that the science curriculum undermine the inherent logic of the subdivision of courses, and 86.5 percent of science teachers think students have more difficulty in building a framework of knowledge. In addition, 59.5 percent of science teachers think that the science curriculum is relatively difficult for the in-depth discussion and learning of students. As to inquiry activities for science curriculum, 30.4 percent of science teachers believe such activities to be too much to carry out (Figure 2).

Development and Utilization of Science Curriculum Resources

Curriculum resources comprise the sum of all be available in the entire curriculum development process of curriculum design, implementation and evaluation. It contains all kinds of materials from school, family and society to help students' literacy improving. Curriculum resources are not only the carriers of knowledge, information and experience, but also the media for curriculum implementation. (Xu, 2002) As an important resource, the science textbook is the main content in curriculum

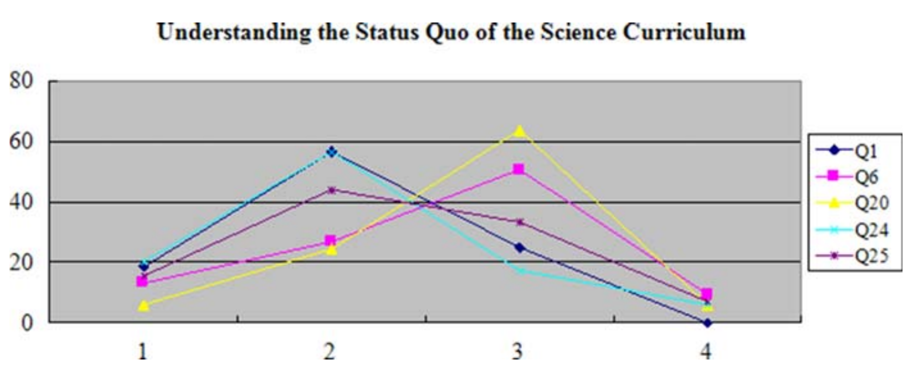

Figure 2. Understanding the status quo of the science curriculum.

implementation for science teachers. According to the survey, science teachers call for the reform of science textbooks, which means science textbooks are important for science teachers. Textbooks should consider the relationship of science structure (logic relationship between the various fields of science, the balance of difficulty of each grade segment) and disciplinary relations (science and mathematics, Chinese of primary). In contrast, the survey reflects the strong dependence of science teachers on science textbooks; even worse, some science teachers regard the teaching materials as their bible, from which they do not dare to deviate. As to the development and utilization of science curriculum resources except the teaching materials, science teachers in different schools have different views. Taking Bingxing School as an example, some science teachers emphasize the development of regional and generative resources, such as non-default experiment resources development, holding experimental exploration to be secondary. They extend science teaching outside the classroom and use interesting science experiment from students' life to replace their assignment.

Curriculum reform on the national, local, and school levels can help schools and students adapt to the curriculum and provide a broad stage for teachers to develop and utilize curriculum resources. However, great differences were evident among the different schools in the three courses because the corresponding mechanisms (such as home-school cooperation, community participation mechanisms, and market-oriented curriculum resources) have not been built.

The development and utilization of science curriculum resources are relatively inadequate. As to the survey of "whether school curriculum resources are abundant," 62.5 percent of science teachers believe that their science curriculum resources are very scarce. Specifically, with regards to the science experiments, approximately half of all science teachers reported that their schools have no full-time lab assistant. In addition, 47.1 percent and 61.2 percent, respectively, of science teachers reported insufficient scientific experiments room and laboratory equipment. Of course, such situations are not only caused by the pressure of science teaching evaluation; science teachers also lack the awareness to develop and utilize the outside curriculum resources, especially the Science and Technology Museum, which requires the convergence of science teaching content and reflection of the important aspects of science, technology and social relations. In the interview, the majority of science teachers preferred multimedia teaching materials, extracurricular experiments, and even teaching reference and exercise books. The reason for such preference could be deduced from further interviews. First, science teachers feel too much pressure to develop and utilize relevant science curriculum resources, which are quite time-consuming. Second, students are short of time to attend relevant inquiry activities because of their heavy workloads. Third, schools try to avoid courses related to curriculum development and utilization in consideration of the safety of students. Fourth, no similar external standardized examination and evaluation tools to evaluate the actual effectiveness of science curriculum resources development and utilization exist. Fifth, due to lack of understanding of curriculum resources, science teachers ignore or fail to grasp the rich student-generated curriculum resources.

Different schools pay different levels of attention to the exploitation of curriculum resources. For example, some schools set up areas such as “Botanical Garden,””Herbarium,” “Geographic Park,” and “Science and Technology Museum” for students to learn and understand science, whereas some schools carry out a variety of practice activities about science, such as competitions about science and technology (e.g., model aircraft competition). Such comprehensive activities are not fully independent of science teaching so that they cannot be regarded as the source of questions about science for students. Students fail to establish the relationship between high-tech and science learning, thereby showing the lack of the understanding of science and technology links. This phenomenon may be part of the reason STS education implementation should focus more broadly on science and its utilization in society.

From the survey about STS education in science education, 72.6 percent of science teachers think the implementation of STS education is often a mere formality. For example, 74.29 percent (Yuhuan County) and 80.26 percent (Jinhua City) of science teachers believe the implementation of STS education is a mere formality.

Scientific Learning Process

Understanding the cognitive development of children and its psychological characteristics would help science teachers to design adaptable course content and use appropriate teaching methods. Namely, science curriculum design and the teaching process depend on understanding the cognitive development and learning characteristics of students. Thus, we design the interview in three levels: whether science teachers recognize the learning mechanisms of students, whether science teachers use learning mechanisms for teaching science, and whether science teachers can self-reflect according to the learning mechanisms.

From the survey and interview, the majority of science teachers emphasized that students experience is important for their science learning. They learn and understand science based on the phenomena and facts they observe and experience. Therefore, most science teachers emphasize scientific experiments and scientific inquiry activities in their science teaching. The relationships among each field of science and science and mathematics (or Chinese) are also emphasized. Taking the topic “measurement of length and volume” of science textbook as an example, students find these books difficult to understand because they cannot use scientific notation in math, which they have not learned in previous grades or classes. In short, not only science teaching, but also the development of science textbook, should consider the relationship of internal logic of scientific disciplines and the links between science and other disciplines.

As to the preconceptions in science learning, science teachers show different levels of awareness across different districts. Most science teachers from Lucheng District have an in-depth understanding of the preconceptions and can distinguish two different kinds of preconceptions by means of specific scientific examples: the original concepts of students and scientific concepts are consistent, though they are low-level, whereas intuitive concepts can be obtained as foundation for scientific concepts.

In addition, the original concepts of students and scientific concepts are inconsistent and will play a hinder impact on the formation and development of scientific concepts. As to the conversion of these misconceptions, the majority of science teachers stress the importance of scientific experiment and inquiry. However, most have limited understanding and only several individual science teachers can cite part of the strategy for the conversion of misconceptions. They show students' contradiction of the original concepts and scientific concepts using guesswork and scientific analysis, and guide students through the experiment and inquiry process to promote the transformation of scientific concepts. With regards to the classification of scientific concepts and conceptual change strategies, most science teachers are unable to clarify the reasons for the discrepancies between misconceptions and scientific concepts, and thus cannot provide a variety of strategies in their teaching behaviors. Professional guidance is therefore crucial.

Regardless of whether the school is in high-tech area, rural or urban, science teachers must consider the differences of students, and then value cooperative learning and their experience process accordingly. Taking Bingxing Middle School as an example, whereas some science teachers can take stratified teaching and the hierarchical design of an assignment to promote the development of a student, few concern themselves with the difference in assessment. However, according to the survey and interview, the majority of science teachers lack an accurate understanding of cooperative learning and its effective strategies, which means they are unable to distinguish cooperation learning, collaborative learning, and group learning. They also do not understand the nature of cooperative learning clearly, and thus lack effective implementation strategies and evaluation needed for professional guidance.

Teaching Process and Its Evaluation

The teaching process reflects the effectiveness of science teaching; thus, the effectiveness of implementation needs to be evaluated. "Teaching to promote learning," which means diluting the selection and increasing the value of evaluation, is put forward in new curriculum reform. Improving the scientific literacy of students is put forward in the science curriculum standards (Grades 7 to 9), which stress the evaluation reform to promote student and teacher development, as well as the effective implementation of science curriculum. (Ministry of Education, 2001).

According to the survey and interview, despite the awareness of science teachers that improving the students' literacy is the ultimate goal of science teaching most continue to focus on scientific knowledge and stress unit tests, midterms, and final exams as the main assessment forms in science teaching and its evaluation. Teachers, not students, are regarded as the main subjects to evaluate, and thus evaluation tools depend on the various types of test questions and exercises, which have distinct pros and cons. Inquiry and cooperation are also stressed in science curriculum standards as a reflection of science teaching; however, the evaluation process of scientific inquiry and cooperative learning, especially the operability of the scientific inquiry evaluation system, is not mentioned. In addition, although 81.3% and 74.3% of science teachers often adapt inquiry learning and cooperative learning, respectively, the majority of the science teachers in the interview do not seem to understand inquiry and cooperation, and thus experience difficulty in carrying out real inquiry teaching in practice. Figure 3 presents the comparison of inquiry in two areas. One point that should be made clear is that science history and method in science teaching show discrepancies with results of the survey of "the nature of science": 73.2%, 82.2% and 77.4% of science teachers, respectively, stress the penetration of history of science into science teaching, elaborate the nature of science combined with the scientific content, and are concerned with science method penetration and education.

With the development of science and technology, and their application in education, we have entered a stage of information technology and curriculum integration (IITC). As a teaching and learning theory, constructivist theory contains "situation," "consultation," "conversations" and "meaning construction," which, due to the popularity of multi-media technology and networks, have a significant impact on teaching practice. From the characteristics of integrated science curriculum that embody comprehensiveness and openness, science curriculum resources are needed to help students learn science from nature and society. As to the science curriculum content, it should involve micro, macro, and macrocosmic scientific phenomena. Abstract science must be transformed into intuitive, specific representations for science teaching, based on IT technology. However, the most application of IT in science education still focus on the graphic video demonstrations for convenient, rapid, and large scale exercises, as well as text and video to stimulate students' interest. In short, the functions of IT integrated into the science curriculum are limited to the visualization of the scientific content, and do not concern its resources function and interactive features. Specifically, when we utilize DIS for science education, the majority of science teachers are unfamiliar with the concept and are unable to use DIS for scientific experiments. This issue has become a great concern in science curriculum reform.

Science Teachers and Their Professional Development

The integration of science curriculum has broadened scientific content to involve geography, astronomy, and aeronautical science. In addition, activities of scientific inquiry and STS topics are stressed in science teaching, putting forward new demands regarding inquiry, problem solving and application for science teachers. The quality and subject knowledge structure of science teachers are key factors. Therefore, whether our science teachers adapt to interdisciplinary characteristics of "Science" course is an unavoidable question that needs serious investigation. According to the

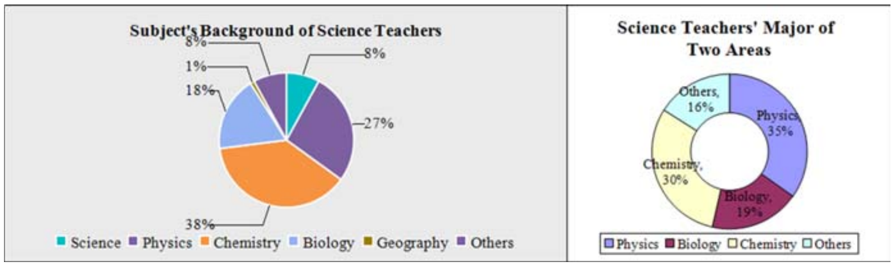

Figure 3. Subject's background of science teachers.

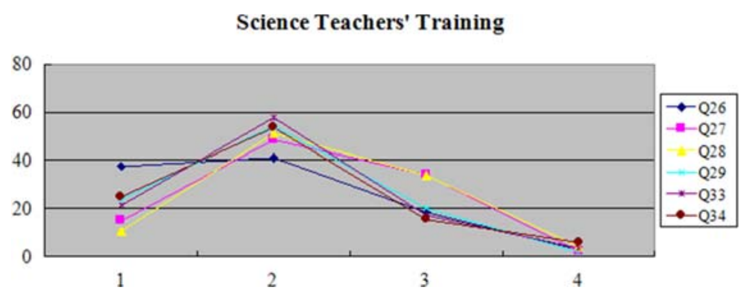

Figure 4. Science teachers' training.

survey, the main force of the science teachers comes from physics, chemistry, and biology majors of normal universities. Few possess other professional backgrounds, as shown in the survey of two areas (Figure 3a, Figure 3b).

Certainly, the implementation of integrated science curriculum in some areas is affected by the professional background of the science teachers. Thus, the "combined science" curriculum form implemented in Grade Three of some junior high schools is consistent with the survey and interview.

As to training and research of science teachers, nearly all regions and schools regularly or irregularly organize teaching and research activities, which are often mainly on the teaching of scientific knowledge for science teachers of different majors. Discussion about development of curriculum resources, teaching strategies and methods, science teaching evaluation and so on are lacking, thereby making in-depth exploration and research on science teaching is difficult (Figure 4).

According to the survey, 78.6 percent science teachers believe outside training opportunities are insufficient, and 63.5% believe science courses seldom carry out school-based teaching and research. Although cooperation and communication are stressed, 78% science teachers think communication mechanisms of different schools are lacking. As to the effective training, 79.1% of science teachers think that not only the content and skills be improved, but also the research and discussion mechanisms.

According to the science teachers, the normal institutions of Zhejiang Province actively participated in the new curriculum reform. Science education majors from different normal universities were set up one by one, such as "science education," was an important major, by Zhejiang Normal University, Ningbo, and Shaoxing Colleges in 2003, and by Huzhou Normal University, Huzhou, and Taizhou Colleges in 2004. These institutions provided professional science teacher candidates for deepening the reform. However, some facts should be considered regarding curriculum design: (1) First, the cultivation of science teachers of different colleges focusing on the various disciplines were present, but an integrated and comprehensive curriculum was lacking; (2) Second, the focus was different for different colleges: mathematics and physics colleges stressed physics, whereas chemical and biochemical colleges focused on the professional basis of biology and chemistry.

The professional development of science teachers is a dynamic, generated, and constructed process, with individual, situational, and constructional elements that require inquiry and communication in the specific context. "A learning community is a group that investigates the problems encountered in the teaching and learning process. All participants will reach a common language about science teaching." According to the survey and interview, science teachers have varying degrees of communication with the other teachers in the same school, and exchanges between the different schools and areas are uncommon.

Convergence of Science Curriculum of Every Segment

Curriculum convergence of primary school and junior high school, and junior high school and middle school, is a common problem faced by the curriculum designers. In short, such curricula must be intrinsically linked and comprehensive. The science curriculum of both follows the development of "nature" and shows the same goals to promote students' understanding of scientific literacy. The content of both concerns biology, humanity, water and air, power and machinery, sound and light, electricity and magnetism, the earth, the universe, and so on. Because of different cognitive characteristics, differences exist in the formation and development of scientific literacy. For primary students, interest in science and thirst for science, scientific activities to experience the process and methods, and understanding the relationship of science, technology, and society are stressed. For junior high school students, understanding the nature of science and the student's science attitude formation are given added stress to promote their understanding and application of STS. In addition, scientific inquiry should also have a different focus because the focus of elementary students is to cultivate the ability to observe, describe, and express their experience of the scientific inquiry process. The students of junior high school should be able to use simple instruments and tools to collect data, record results of observation and measurements, use research processes and results in different ways. For high school students, inquiry activities, systematic observation, and precise determination must be cultivated. Therefore, we should clarify the different requirements of the same scientific content for students of different grades ("mechanical leverage and its applications" is a good example).

Convergence of junior science curriculum and senior subdivided curriculum is the problem in the implementation of science curriculum. From the curriculum content, integrated science curriculum emphasizes breadth of knowledge whiles placing less emphasis on depth, and stresses students' experience of scientific knowledge while placing less emphasis on the systems and logic, resulting in the fragmented grasp and vague understanding of subject knowledge which are clearly demonstrated the incoherent of the science textbook. Therefore, we should pay attention to convergence, not only in complying science materials, but also in the process of teaching and teacher training. "Chemistry (physics, biology) experimental teaching method" is the bond to connect science and subdivided curriculum. Some columns, such as "reaction" and "thinking and communication" also can be the links connecting the junior high school and high school chemistry. In general, both schools must actively participate in the teaching activities to concern convergence not only in content, but also in teaching.

Difficulty of the Implementation of Science Curriculum

Implementation of the integrated science curriculum involves many aspects that are important to the effective implementation of science curriculum. We designed open-ended questions of survey such as "What do you think is the major difficulties encountered in your science teaching?"; "How do you solve such problems?"; "What is the great difficulty facing the science curriculum?" and "What measures must be taken to ensure science curriculum implementation?" According to the survey, the professional background of science teachers is the main factor for effective science curriculum implementation. Most science teachers feel the lack of relevant knowledge and then spend much time to prepare despite their years of teaching experience (Figure 5). According to the survey, 75.2% of science teachers

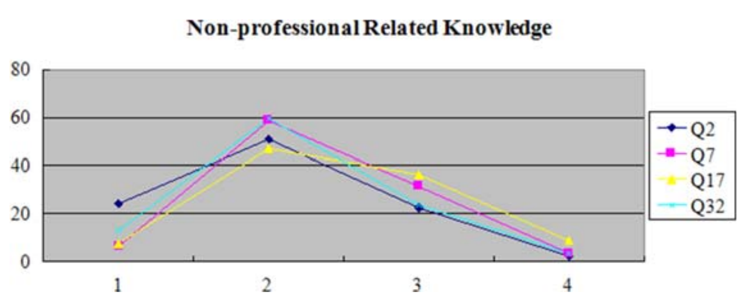

Figure 5. Science teachers' non-professional related knowledge.

feel the lack of non-professional related knowledge in their teaching, 65.1% of science teachers do not fully grasp the integration of science curriculum, and 45.2% are not proficient with the experimental skills, except for those covered by their major. Therefore, 72.6% of science teachers are greatly lacking in non-professional knowledge and experimental skills.

Difficulties in the implementation of scientific experiment and scientific inquiry not only stem from the demonstration experiment arranged in textbooks, but also due to the lack of laboratory equipment and professional lab assistants. The lack of modern equipment hinders the capacity of science teachers to design experiments, which results in "multi-media experiments" and "blackboard experiments" instead of scientific experiments. The science textbook is another difficulty for science curriculum effective implementation.

The examination and evaluation system of the science curriculum, including the matching degree of difficulty of teaching content and examination question, was also difficult to implement effectively. According to the survey, scientific evaluation standards need to be identified. People's opinions regarding evaluation as "the writer and advocator of science curriculum evaluate the implementation normally according to their experience" and "the opponent of science curriculum generally evaluates the science curriculum implementation according the standard of the subdivision of curriculum" need to be changed.

REFERENCES

Fang, H. (2006). *Structural design analysis of science textbook (Basic education curriculum 3)*. Zhenjiang: Zhejiang Education Publisher.

Guo, Y. (2002). *From traditional to modern – the development of integrated science curriculum.* Beijing: Beijing Normal University.

Lin,J. (2004). Survey and analysis of science curriculum implementation in junior school of Wen Zhou. *Curriculum Reform Information of Zhejiang*, *13*, 44–52.

Li, Y. (2006). The morphological analysis and system construction of integrated curriculum. *Educational Research*, *12*, 43–47.

Michael, F., & Pomfret, A. (1977). Research on curriculum and instruction implementation. *Review of Educational Research*, *47*(3).

Ministry of Education of the People's Republic of China. (2001). *Science curriculum standards (grades 7–9) of compulsory education*. Beijing: Beijing Normal University Press.

Pan, S. (2004). *From division to integration – on science curriculum setting*. Doctoral Dissertation, Shanghai: East China Normal University.

Sun, D. (2010).*Content integration of mainland integrated science curriculum*. Doctoral Dissertation, Shanghai: East China Normal University.

Xu, J. (2002). Development and utilization of curriculum resources. *Interdisciplinary Education*, *2*, 30–36.

Yan, X. (1991). The idea of "Natural Science" curriculum structure in junior high school. *Journal of Hangzhou Educational College*, *2*, 45–46, 68.

Yu, H. (2003). *Interpretation and construction of science curriculum culture*. Doctoral Dissertation, Lanzhou: Northwest Normal University.

Yu,Z.(1996). On the curriculum basis for "Natural Science".*Curriculum Development*. *Interdisciplinary Education*, *1*, 23–26.

Yu, Z. (2002). *Science curriculum*. Beijing: Education and Science Press.

Yu, Z. (2011). *Integrated science curriculum design*. Hangzhou: Zhejiang Education Press.
Zhang, H. (2007). On new curriculum implementation affects to scientific literacy of graduate students. *Journal of Zhejiang University of Media and Communication*, *2*, 49–50.
Zhou, Y. (2010). *Paradigm development of integrated science curriculum*. Beijing: Science Press.

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