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A Comparative Study of Secondary Chemistry Education in Korea and China

Wha-Kuk Lee, Chinhyu Hur &
(Chonbuk National University)
Zhou, Chuan
(Suzhou University)

ABSTRACT

The purpose of this study is to compare and analyze secondary school chemistry education in Korea and China in order to identify implications for the improvement of Korean chemistry education. The school systems, curricula, and teacher education related to secondary chemistry education of both countries were compared and analyzed. The 6-3-3-4 school system is used in both countries, and national school curricula are formulated by the Ministries of Education in both countries. The 1996 chemistry curricular standard for advanced middle schools in China, and 1997 chemistry curriculum for Korean high schools were compared in several aspects, followed by comparisons of chemistry teacher education in both countries. Based on the comparative analysis of chemistry education, some ideas and issues which provide implications for improving Korean high school chemistry education were identified. Chemistry teaching in the junior secondary schools, tentative implementation of curricula, required course work in chemistry, structure of curricula, oral assessments, probation of teachers and other issues are identified and discussed in this study.

Key words: chemistry education, Korea, China, curriculum, teacher education

I. Introduction

Korea and China had very strong cultural relations until the end of the second World

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War when the two countries became hostile due to different political ideologies. Fortunately, a cooperative relationship between the countries was restored after four decades of cultural separation. During the separation, chemistry education in the Republic of Korea (hereafter "Korea") had been developed based on the American system, and development of chemistry education in the People's Republic of China (hereafter "China") was strongly influenced by the Soviet Union (He and Bi, 1996). In the late 1980's, the western economic system was introduced to China after the fall of the Soviet Union, and so also was introduced western chemistry education.

China is a country with one-fifth of the world's population, and is likely to be a powerful world leader in the near future. Therefore, we need to understand China's chemistry education system, the impetus of China's industrial development and economic growth. Moreover, research on chemistry education in China can provide an understanding of chemistry education in North Korea. which will be essential for science education policies after unification of Korea. Recently school education in China has been studied by several researchers (Koo, 1997; Pack, 1997; Lee, C., 1999; Lenin, 1987; Wang, 1996), but comparative study on school chemistry education is very limited (Lee, W. 2000; Lee, K., 2001). The intention of this study is to compare and analyze chemistry education for senior secondary school in China and Korea in order to discover issues and ideas which might provide implications for improving chemistry education in Korea. Outlines of the education systems of both countries were reviewed and various aspects of their curricula were compared followed by brief comparisons of their chemistry teacher education systems.

The study was carried out mainly through literature analysis and interviews. After surveying the literature on chemistry education in Korea and China, the authors made exchange visits to Korea and China to collect additional information and to interview science education specialists of both countries.

II. Outline of the educational systems

1. School systems

School education in Korea and China is composed of three stages: primary school, junior secondary school and senior secondary school, under the 6-3-3 system as shown in Fig. 1. Secondary schools in China are called "basic middle schools" and "advanced middle schools", since "high school" means college and university in China. Korean junior and senior secondary schools are called "middle schools" and "high schools".

Primary and junior secondary education is compulsory in both countries. Children enter primary and elementary schools at age six. Primary school graduates in China advance to basic middle schools without examination, but in order to enter advanced middle schools

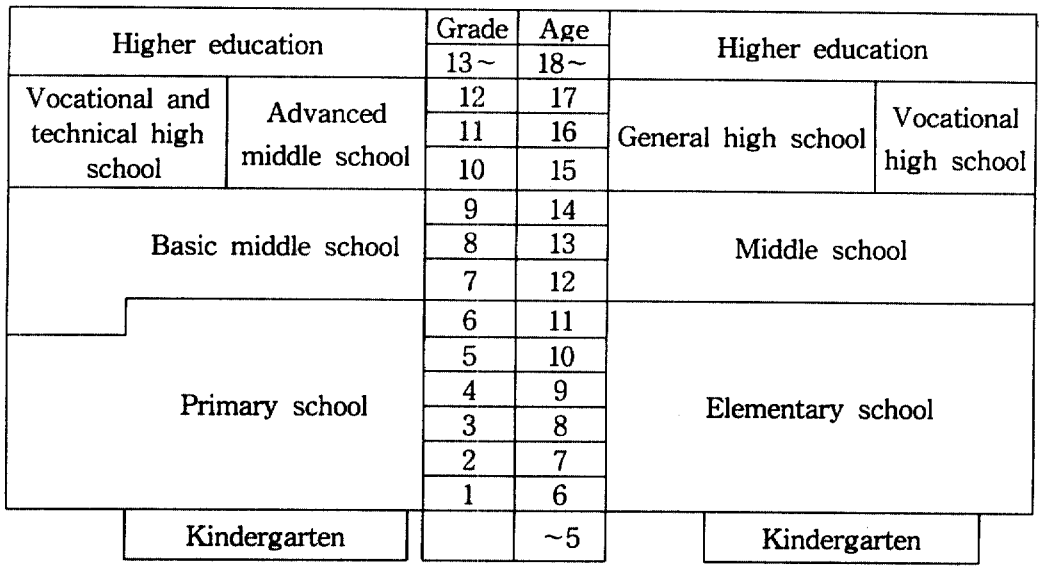

Fig. 1. School systems of Korea and China

basic middle school graduates must pass examinations set by local education authorities. In 1998 the net enrollment rate of primary school age children attained 98.9%, and the proportion of primary school graduates continuing their study in junior secondary schools (including vocational ones) reached 94.3% (CERNET, 2000). But only half of the graduates from the basic middle schools entered one of the three types of senior secondary schools: key schools, ordinary schools, or vocational/technical schools. In Korea, nearly all middle school graduates enter high school with or without entrance examination.

Except for a small number of private schools established recently, most secondary schools in China are public. Curricula of key schools are not different from those of ordinary schools, but the facilities, teachers and other conditions of education are much better in the key schools. As a result, in China entrance examinations for the good key schools are very competitive, as are the entrance examinations for the key universities. In Korea there are more private high schools than public high schools, but there aren't any particular differences in teaching between them. The Korean government provides large subsidies to private secondary schools.

The school year in China is divided into two semesters as in Korea. The teaching sessions of a school year for the primary, basic and advanced middle schools in China are 38, 39, and 40 weeks respectively. China's school year begins in September and ends in July, and since 1995 students go to school five days a week. The teaching sessions in Korean schools are shorter than in China, 34 weeks a year, but students attend schools on

Saturday mornings. The new school year in Korea begins in March.

Secondary chemistry education is based on the national curriculum in Korea, and on national curricular standards in China. The Ministry of Education and Human Resource Development in Korea (hereafter "KMOE"), and Ministry of Education in China (hereafter "CMOE") are responsible for the formulation of the national school curricula. Chemistry textbooks based on national curricula must be evaluated by the Ministries of Education in both countries, and they are considered the basic guidelines of school chemistry education.

2. Educational administration system

Korea and China are countries with very powerful central governments which exercises macro guidance over all education, leaving its actual management to local governments. In both countries the Ministries of Education are responsible for formulating laws and regulations, policies and overall planning, and the basic elements of the education system; for providing funds for school education, and for general supervision and guidance of the work of the local educational administrative departments.

The responsibilities of provincial-level governments in China are to implement basic education in areas under their jurisdiction, including the design of development plans and teaching plans for local primary and secondary schools; the organization of student evaluation, and the establishment of special educational funds to help poor and minority areas and provision of subsidies to counties with inadequate educational expenditure (CERNET, 2000). Implementation of compulsory education, including the overall management of educational finance, the deployment and management of school principals and teachers, and the provision of guidance for education and instruction in primary and secondary schools are responsibilities of county-level governments.

School curricula are designed by curricular standard formulated by the Ministry of Education in China. Local governments and individual schools can provide additional subjects. Chinese secondary schools are more independent than Korean schools in their management. In China many advanced middle schools operate their own businesses, which cover part of the teachers' salaries. Teachers salaries, therefore, differ from school to school.

Educational administration in Korean high schools is rather uniform. Chemistry teachers for public high schools are recruited and deployed by the superintendent of the City and Provincial Office of Education. Teachers may stay only several years in a public high school before he moves to another public school in the city or province. High school teachers in private schools, however, may stay in a school until retirement.

In China, there is only one kind of chemistry textbook published by the People's Educational Press. But several kinds of chemistry textbooks are published in Korea by different publishing companies. So, each school can select any chemistry textbook.

Chemistry teachers, science head teachers and principals are responsible for selecting textbooks. Important management decisions in each high school in Korea are made by the committee of management of the school, composed of representatives of parents and teachers.

Ⅲ. Senior secondary chemistry curricula

1. The characters and objectives of school curricula

In Korea, the school curriculum is developed by the Ministry of Education. Specific guidelines for organization and management of the curriculum are determined and implemented by each City and Provincial Office of Education (KMOE, 1992, 1997). But there are no noticeable differences in chemistry education among provinces and schools.

In China, school curriculum is organized by local governments and schools based on the curricular standard formulated by the Ministry of Education. The current advanced middle school chemistry curricular standard was announced by the National Committee in 1981, and was finally revised in 1994. But in 1996 a new curricular standard was developed. It was implemented in four Provinces in 1997. Pilot implementation of the new curriculum expanded to fifteen provinces in 2000 (Zhou, 2000).

A new secondary chemistry curriculum is also partially implemented in Korea. The sixth chemistry curriculum issued in 1992 is used together with the seventh curriculum issued in 1997. The schedule for the implementation of the seventh Korean science curriculum is shown in Table 1. (KMOE, 1997).

The goals and aims of Chinese chemistry education are "providing students with basic knowledge and skills for mastery of scientific thoughts and methods, development of abilities, character, specialties, and improvement of creativity and practice to participate in establishment of communism and to build a solid foundation for lifelong learning" (CMOE, 2000; He, and Bi, 1996).

Table 1. Implementing schedule for the seventh Korean science curriculum

Academic year	Implementing school and grade		
	Primary school	Middle school	High school
2001	Grade 3 & 4	Grade 1	
2002	Grade 5 & 6	Grade 2	Grade 1
2003		Grade 3	Grade 2
2004			Grade 3

Three goals of chemistry education, namely knowledge-skills, intellect and ability, and scientific attitude are the same as the goals of chemistry education in Korea. But instead of the goal of establishing communism in China, education for democratic citizen is an important goal of education in Korea. In Korea's seventh curriculum, chemistry is divided into "Chemistry I" and "Chemistry II", and objectives of the two subjects are differentiated. "Chemistry I" is a subject for "investigation of natural facts and materials to understand the basic concepts and to have knowledge needed as a democratic citizen", and "Chemistry II" is for "developing problem solving ability applying advanced concepts and various investigation methods". But both subjects maintains the same goals, which are "understanding the basic concepts, promoting interest in chemistry, and being aware of the affect of chemistry on techniques and society" (KMOE, 1997).

2. Historical development of the chemistry curriculum

Chinese secondary chemistry education began in 1865 when the Ching dynasty established a machinery school in Shanghai and included chemistry as a school subject. In 1903 the Chinese government formulated laws of the school system and chemistry course, and chemistry education was officially introduced. The Republic of China adopted the 6-3-3, primary - junior secondary - senior secondary school system in 1922, and chemistry was taught beginning in the second grade of the junior and senior secondary schools. And in 1929, a new curricular standard was issued. Chemistry classes consisted of five hours of lecture and one hour of laboratory class per week to the third-graders of junior secondary schools, and three hours of lectures and three hours of laboratory class per week for the second-graders in senior secondary schools.

Since the foundation of the People's Republic of China several changes in school curricular standards made, but chemistry has been maintained as an important subject. Sometimes chemistry was taught beginning in second grade of junior secondary school, but in general it has been taught from the third grade of the junior secondary to the third grade of senior secondary schools. The historical development of Chinese secondary chemistry education can be inferred from the development of the textbooks for the secondary schools (He, and Bi, 1996).

(1) The first period (before the foundation of the Peoples Republic of China): foreign textbooks translated into Chinese were used.
(2) The second period (1949-1957): secondary school textbooks of the Soviet Union were translated into Chinese and published for school use.
(3) The third period (1960-1966): textbooks were compiled based on past experiences
(4) The fourth period (1977-): textbooks are developed based on experiences and adoption of foreign techniques of textbook compilation.

Chemistry education in China was formerly influenced strongly by the Soviet Union. Beginning in the mid-1980s self-development became possible. Chemistry education in China had been related to politics, and the cultural revolution destroyed nearly all chemistry education in China. But during the last two decades chemistry education in China has been restored gradually (Fan, 1992; Zhang, Zha, ,Li, & Zhang, 1996). Currently 1996 chemistry curricular standards for advanced middle schools are in use, but a new chemistry curriculum for the advanced middle schools has been put into a pilot test on a small scale (Luo, 2001).

Korean chemistry education was also introduced in the late 19th century through the Christian mission schools. More formal chemistry education was started under Japanese rule. After Korea gained independence, the American military government implemented the American model of chemistry education. The development of chemistry education for the last half century can be traced through the changes in chemistry curriculum for high schools (Study Committee for Curriculum and Textbooks, 1990; Han, 1992; Choi, 1997)

(1) Syllabus period (1946-1954): Syllabus developed by the Syllabus Committee of the American military government in September 1945 was implemented on the 1st of September, 1946. Chemistry was taught 110 hours as a required subject and 80 hours as an elective in high schools.

(2) The first curriculum (1954-1963): The Curriculum Committee, organized in 1953, formulated a decree concerning time allotment for school curriculum in 1954. Chemistry textbook compilation was completed in 1958. The curriculum was influenced by the American progressivism, and students' interests and life experiences were emphasized. Student selected one subject from physics, chemistry, biology, and earth science as the required subject in the first grade, and from one to three subjects were optional.

(3) The second curriculum (1963-1973): Government established by military revolution evaluated the education system and developed the school curriculum in 1963. The curriculum was based on life or experience centered trends in education. The chemistry curriculum was put into effect in 1968. Chemistry I (five units) was a required subject for the humanities track, and chemistry II (twelve units) was a required subject for the science track.

(4) The third curriculum (1973-1981): The 1971 Long-term Educational Planning Committee prepared a draft curriculum, and it was put into public hearing and deliberation of the Curriculum Committee. The curriculum was pilot tested for two years and finally issued on February 14, 1973. The chemistry curriculum reflected discipline-centered curriculum trends of the 1960's United States, and structure of knowledge, understanding of concepts, and inquiry skills were emphasized. Students in the humanities track selected two out of four science subjects; physics, chemistry,

biology, and earth science (eight to twelve units each). All four subjects were taught as required subjects for students in the science track.

(5) The fourth curriculum (1981-1987): The curriculum developed by the Korea Educational Development Institute (KEDI) in 1978 was issued in 1981 by the Ministry of Education. In addition to the previous subject, experience, and discipline-centered trends in curriculum development, a human-centered trend was now reflected in the curriculum. High school chemistry was divided into chemistry I (four to six units) and chemistry II (four units). Chemistry I was a required subject for all students, but chemistry II was required only for the students in the science track.

(6) The fifth curriculum (1987-1992): The Ministry of Education started revising the curriculum in from 1985. The revised curriculum developed by the KEDI was issued in June, 1987, based on comprehensive educational trends. Improving the effectiveness of the curriculum was emphasized. "Chemistry I" of the fourth curriculum was combined with "Physics I" to form "Science I", and "Biology I" and "Earth Science I" were combined as "Science II". Science I and II were required subjects for students in the humanities track. But students in the science track were required to study Science I, Physics (eight units), and Chemistry (eight units) and Biology (six units) or Earth Science (six units) as elective subjects.

(7) The sixth curriculum (1992-1997): Curriculum suitable for the preparation of the 21st century was the principle of curriculum development. Keeping the general framework of the discipline-centered trend, topics of everyday life which attract students' interests, and contents related with real life were introduced due to the STS movements. Four science subjects were divided into I & II subjects, and the I and II subjects were required subjects for the students of humanities and science courses respectively.

(8) The seventh curriculum (1997-): The seventh curriculum was developed by the Korea National University of Education, and was issued at the end of December, 1997. General science is taught from the third grade of primary school to the first grade of high school as a National Common Basic subject. All four science subjects are divided into I & II subjects, and students study the I subject in order to study the II subject. The distinction of humanities and science tracks was removed, and chemistry I & II as well as other I & II science subjects became elective subjects for the second and third grade students.

Comparing historical development of chemistry curricula in Korea and China, we see that curriculum development is more systematic in Korea. Korean chemistry curricula were influenced by western educational trends such as subject, experience, discipline, and human centered curricula, whereas the Chinese curriculum was influenced by educational theories of the Soviet Union. The organization of science subjects including chemistry for the

advanced middle schools has not been changed in China, but it has been changed in many different forms in Korea.

Table 2. Organization of the sixth and seventh curricula for general high schools in Korea

Classification	The sixth curriculum	The seventh curriculum
Organization	Subject matters, optional & extracurricular activities	National common basic course: subject matters, optional & extracurricular activities High school elective course: subject matters, and extracurricular activities
Subjects	Ethics, Korean, Chinese Letters, mathematics social studies, science, physical Education military training, music, fine arts, practical arts · home economics, foreign language (english), liberal education	Korean, moral education, social studies mathematics, science, technology · home economics, physical education, music, fine arts foreign language (english), Chinese letters, liberal education
Extracurricular activity	Class, school, club and group activities	Self government, adaptation, development, service, and function activities
Types of courses	Humanities · social, natural, vocational and others	Courses are not classified

3. Organization of high school curriculum and time allotment of science subjects

The high school curriculum of Korea is in transition from the sixth to the seventh curriculum. Many differences are found in general high school curricula as shown in Table 2. Under the seventh curriculum, first grade students must complete the national common basic track, and individual students in the second and third grade must organize their own elective track. Accordingly, there are no distinctions of humanity, science, and arts tracks as existed previously.

The time allotment of science subjects has also changed noticeably as in Table 3. In the seventh curriculum, "Common Science" is substituted for "Science 10". Due to the influences of the STS movements in science education, a new subject called "Life and Science" has been is introduced. Physics, chemistry, biology and earth science are divided into 'I' and 'II' as in the sixth curriculum, but students must complete the 'I' subject prior to learning the 'II' subject. As the distinction of the humanity and the science courses has been

removed, students' choices of elective subjects are widened in the seventh curriculum.

Table 3. Names, time allotment, and selection forms of high school science subjects in Korea

Classification	The sixth curriculum	The seventh curriculum
Subject types	General compulsory: common science (8) Course compulsory: physics I (4), physics II (8) chemistry I (4), chemistry II (8), biology I (4) biology II (8), earth science I (4) earth science II (8) Course elective: course compulsory subjects which are not selected	National common basic: science (8) General elective: Life and science (4) In-depth elective: Physics I (4), physics II (6), chemistry I (4), chemistry II (6), biology I (4), biology II (6), earth science I (4) earth science II (6)
Choices of subject selection	Humanities course: physics I, chemistry biology I, earth science I (Total: 16) Science course: physics II, chemistry II, biology II, earth science II (Total: 32)	1 subject (4) ~ 9 subjects (44)

* The figure in ( ) indicate the number of credit unit

The curricula for advanced middle schools in China consist of subjects and activities. The State required subjects are Moral Education and Politics, Chinese Language, Mathematics, Foreign Language, Physics, Chemistry, Biology, History, Geography, Physical Education, Musics, Fine Arts, and Labour-Technology. Local governments or schools add a number of elective subjects (Koo, 1997; State Commission of Education, 2000).

Table 4 shows the structure of science subjects in the 1996 curricular standards for advanced middle schools. Hours of instruction for required and elective subjects as presented in the Table. Time allotment of chemistry is less than that of physics, but more than that of biology.

Table 4. Science subjects of the 1996 curricular standard for the advanced middle schools in China

Subject	Class hours a eeek			Total class hours for three years
	Required	Elective	Total	
Physics	4-5	5	9-10	158-306
Chemistry	4	4	8	140-271
Biology	3	3	6	'105-183
Total	11-12	12	23-24	403-742

* One class hour last 45 minutes

Comparing the organization of senior secondary school curricula and time allotment of science subjects in Korea and China, the following differences were identified.

(1) "Science" is a subject area in which Physics, Chemistry, Biology, and Earth Science subjects are included in Korea, but Physics, Chemistry and Biology are considered as separate subjects in China. Earth Science is not taught as a science subject, but concepts of Earth Science are taught in Geography and Physics classes in China.

(2) In the first grade, Korean students learn "combined or integrated science" which does not exist in China.

(3) Chemistry in both countries is divided into "Chemistry I" and "Chemistry II", but Chemistry I is a required subject only in China.

(4) Time allotment for science subjects in China is larger than that of Korea by four units for the humanity track and six units for the science track.

4. Structure and form of curriculum

The structure and form of school curriculum documents is quite different from country to country. Korean and Japanese curricula have rather simple structure and form compared with the National Curriculum of England, and frameworks of the U.S and Australia (AAAS, 1993; NSTA; DFEE & QCA, 1999). The Chinese curricular standard lies in between. The 1996 Chemistry Curricular Standard for Full Time Advanced Middle School" is described in a small booklet of 57 pages. The curricular standard is composed of Introduction, Aims of Instruction, Arrangement of Courses, Teaching Contents and Requirements, Instructional Facilities, Teaching Tips, and Inspection and Assessments (CMOE, 2000).

Table 5. Levels of teaching for advanced middle school chemistry in china

Areas	Level	Definition of the level
		After teaching students should be able to;
		• recognize learned knowledge
Basic concepts	A	• memorize the point of learned knowledge
& principles	B	• understand concepts and basic principles, and solve
	C	simple chemistry problems
		• analyze relations of knowledge, and solve simple
	D	chemistry problem
		by applying these knowledge
Use of apparatus	a	• do the experiment under the supervision of teacher
& experimental	b	• do the experiment accurately under the supervision
skills	c	of teacher
		• do the experiment independently

A special feature of the Chinese curricular standard is that levels are assigned as instructional requirements for each learning concept. Four levels similar to Bloom's taxonomy are used for chemistry concepts and basic principles, and three levels are used for use of apparatus and experimental skills as shown in Table 5. (Bloom, 1956).

Compared with Chinese curricular standards, the structure and form of high school chemistry curricula in Korea is relatively simple. Characters, Objectives, Contents, Teaching-Learning Methods, and Assessments of Chemistry I and Chemistry II are described in 12 pages (KMOE, 1997). Table 6 shows some similarities and differences of structure and form of senior secondary school chemistry curricula in China and Korea.

Table 6. Structure and form of senior secondary school chemistry curriculum in China and Korea

Chinese curriculum	Korean curriculum
<Characteristics of curriculum is described in the introduction>	Characteristics of Curriculum
Aims of instruction (3 paragraphs)	Objectives (4 sentences)
Courses and time allotment	Courses and time allotment
Contents & level of teaching (detailed)	Contents (Simple & without level)
Instructional Facilities	Mentioned simply in the methods of of teaching & learning
Teaching tips (detailed)	Teaching-learning methods (simple)
Test and assessment	Assessment

5. Contents of chemistry subjects

Teaching and Learning contents are major parts of curricula. Chemistry II in the Chinese curricular standard is similar to a combination of Chemistry I and Chemistry II in the Korean curriculum. Table 7 shows the contents of Chemistry II in 1996 Chinese curricular standards, and the contents of Chemistry I & II in the 1997 Korean curriculum (CMOE, 2000; KMOE, 1997). There are many commonalities between the contents of Chemistry curricula in Korea and China, but the following differences are found (LEE. W., 2000).

- The largest part of the contents in Korea is theoretical chemistry, but in China the chemistry of elements and compounds occupies about 65% of the contents (He and Bi, 1996).
- Scientific inquiry is included as a part of the contents only in the Korean curriculum.
- Twenty-seven specific topics of chemistry experiments are suggested in the Chinese curricular standards, but not in Korean curricula.
- Basic chemical calculation, use of apparatus, and experimental skills are included only in

the Chinese curricular standard.

• Relations to everyday life is emphasized in Korea, but industrial applications are emphasized in China.

• In Korea, acids and bases are dealt with separately, but they are dealt with as a part of electrolytic solution in Korea.

• Properties of gases and liquids are more important in Korea than China, but types and properties of crystals are more important in China than Korea.

• The scope and level of organic chemistry contents in Chinese chemistry are broader and higher than in Korea.

6. Plans for evaluation of students' achievements

The level of learning contents, and evaluation methods of students' achievement are important components of curriculum. Therefore, in the National Curriculum of England, the level of each concept is presented specifically as an "attainment targets", which is used not only for instructional planning but also for evaluation (DFEE & QCA, 1999). However, plans for evaluation presented in the chemistry curriculum of Korea and China are very simple.

In the curricular standard of China, the function, contents and methods of evaluation are described in one and a half pages under the title of 'inspection and evaluation'. Use of oral tests, assignments, and written tests are suggested for inspection and evaluation of chemistry knowledge, and observation, design and operation of experiments for inspection and evaluation of experimental operations. Assignments such as a short essay, investigation report, experiment report are used for inspection of research tasks, and observation, conversation, interview, and behavior analysis are used for evaluation of emotion and attitude. In addition, self-evaluation under the teacher's guidance is emphasized.

On the other hand, guidelines for evaluation of Korean chemistry curricula are simple and contain the following (KMOE, 1997):

• Investigating ability and scientific attitude are evaluated equally with understanding of concepts.

• Various evaluation methods such as written test, observation, evaluation by report and questionnaire, discussion and interview should be used.

• To increase the validity, develop assessment tools in cooperation between teachers.

• Evaluation should be based on established standards, and the results of evaluation should be used for the improvement of instructional planning and teaching methods.

• The evaluation plans presented in the curricula of Korea and China are similar, but the following differences were identified.

• In the curricular standards of China, the content and level of evaluation are clear because expected levels of the content and instruction are presented in detail. But in the Korean curriculum, the content is presented in brief and there are no expected levels of instruction or evaluation.

Table 7. Contents of senior secondary chemistry curricula in korea and china

Chemistry I & II (Korea)			Chemistry II (China)
Common materials	Properties of water	Knowledge of elements & compounds	Halogen group
	Reaction in aqueous solution		Oxygen group
	water and our life		Industry of sulfuric acids
	Matters in the air		Nitrogen group
	Properties of air		Carbon group
	Pollution of air		Typical properties of metal
	Properties of metal		Alkali metal
	Reactivity of metal		Magnesium
			Aluminium & it's compounds
Chemistry & human	Properties of carbon compounds		Iron & it's compounds
	Carbon compounds & our life		Alkali earth metal & it's use
	Detergents		
	Medicines		
State of matter & solution	Tasks of chemistry	Basic concepts & principals in chemistry	Organic compounds
			Hydrocarbon
			Derivatives of hydrocarbon
	Gases		Carbohydrates & protein
	Liquids & solids		Synthetic materials
	Solution & solubility		Identification of ions
	Concentration of solution		Design of chemistry experiments
	Properties of dilute solution		Amounts of matter
Structure of matter	Atomic structure		Electrolytic solution
	Atomic model & electron		Colloids & it's application
	Configuration		Types & properties of crystal
	Periodicity		Periodicity & periodic table
	Types of chemical bond		Chemical bond
	Covalent bond & molecules		Chemical reaction & energy
Chemical reaction	Changes of matter & enthalpy		Chemical reaction rates & equilibrium
	Bond energy		Oxidation & reduction
	Reaction rates		Principles of primary cells & it's application
	Application of chemical equilibrium		Principles & applications of electrochemistry
	Acids & bases		
	Neutralization		
	Control of acids-bases in the body	Student Experiments	27 Experiments including neutralization & measurement of heat of reaction
	Oxidation & reduction		
	Chemical cells & electrolysis	Chemical Calculations	6 Areas including heat of reaction, & concentration of solution
Investigation	Experiments	Lab Practice	11 Optional experiments
	Survey	Use of Apparatus	5 Apparatus including buret & alcohol lamp
	Discussion		
	Field Trip	Experimental Skills	13 Skills including filtration, & collection of gases
	Projects		

• In the curricular standards of China, lists of skills are presented for evaluating use of apparatus and experimental operations. But in the Korean curriculum, objects of investigative and operative abilities that are under evaluation are not presented.

• In China, oral tests are widely used, which is a general evaluation method in communist countries, but not in Korea (Zhou, 2000).

Ⅳ. Secondary chemistry teacher education

1. Teacher education system

Teacher education is an important part of the education systems in Korea and China. For the last half century both governments at different levels have given priority and great care to teacher education. Since the 1970's the teacher education system has been is fully established in Korea. China is trying to establish a teacher education system that meets the needs of basic education of different levels. Teacher education is divided into pre-service training and in-service training in both countries.

In China, school teachers are principally trained at the independent teacher training institutions supplemented by training at other educational organizations. The separate teacher training institutions in China reflect the Soviet influence of the 1950s (Surowski, 2001). Four-year teacher training institutions including normal universities and colleges train teachers for the advanced middle schools, and three-year teacher training colleges trains the basic middle school teachers. In-service training is conducted by education institutes and in-service teacher training schools. In addition, in-service training programs for teachers are provided through correspondence education programs, evening schools, satellite TV education, and the examinations system for self-directed learners.

As opposed to the Chinese separate teacher training institutions for chemistry teachers, Colleges of Education in the comprehensive universities train chemistry teachers, but primary school teachers are trained by the independent University of Education. All teacher trainees are high school graduates and they study four years to get a degree and the certificate for teaching in elementary or secondary school. Teacher training institutions also provides in-service teacher education, but the major institutions for the in-service training are the In-service Training Centers founded in sixteen cities and provinces. Table 8 shows some aspects of school teacher education in Korea and China, and what follow are some differences related to secondary chemistry teacher education (Lee, K., 2001).

• Chemistry teachers for junior secondary school and senior secondary school are trained by the same institutions in Korea, but by different institutions in China.

• The length of training for teaching junior secondary school and senior secondary school is the same in Korea (four years), but it is different in China (two to three years versus four years).

Table 8. Teacher education systems in Korea and China

Classification	Major training institutes		Enrolling students		Length of study	
	Korea	China	Korea	China	Korea	China
Kindergarten teacher	Junior college	Secondary normal school	High school graduates	Basic middle school graduates	2 years	2-3 years
Primary teacher	Teachers college	Secondary normal school	High school graduates	Basic middle school graduates	4 years	3-4 years
Junior secondary teacher	College of education	Junior normal college	High school graduates	Advanced middle school graduates	4 years	2-3 years
Senior secondary teacher	College of education	Normal university	High school graduates	Advanced middle school graduates	4 years	4 years

• Teacher certificates can be obtained by examination based on self-directed learning in China, but attendance in universities and colleges is obligatory to get teacher certificates in Korea.

• In-service training programs for teachers are provided through correspondence education programs and satellite TV education in China. Cyber in-service programs are expanding rapidly in Korea.

All education including teacher education was free in China up to the mid-1990's, but higher education is not free anymore. Therefore students or their parents must pay tuition and fees to take teacher training, but most in-service training expenses are supported by the schools or local governments. In Korea pre-service teacher training is not free, but since most chemistry teacher training programs are provided by the national universities about half of the tuition is supported by the central government. In-service teacher training was formerly free in Korea, but for-pay in-service training programs were introduced recently and they have been expanded gradually.

2. Pre-service training of chemistry teachers

Secondary school chemistry teachers are trained by general higher teacher education institutions in China.. In 1998, there were 229 general higher education institutions in China with an enrollment of 690,000. Normal universities, teacher-training institutes and teacher training colleges enroll graduates from advance middle schools. Four-year programs are offered for training advanced middle school teachers, and two-three year programs are train teachers for the basic middle schools. The general higher teacher education institutions

also offer postgraduate programs, and they are also playing active parts in providing in-service training for secondary school teachers.

The number of chemistry teacher training institution in Korea is very small compared to Chinese institutions. Only a dozen national universities and a few private universities offer programs for the initial chemistry teacher training in Korea. After four years of training graduates get a teacher certificate for the middle and high schools. In Korea, secondary science teachers should be able to teach middle school combined science and one high school science subject out of physics, chemistry, biology and earth science. But the Ministry of Education changed the decree for teacher certification, and now there are five secondary science teacher certificates; (combined) science, physics, chemistry, biology and earth science. So, most students in the department of science education take the combined science program and one more science program as double major.

In China, graduate programs are offered by only a small number of teacher education institutions including key normal universities such as Peking Normal University, but Nearly all Colleges of Education in Korea provide Master of Education programs. Ph.D. programs in chemistry education are offered by Seoul National University and Korea National University of Education, which is similar to a key normal university in China.

The curriculum of a normal university in China is made up of 4 four parts: compulsory courses, optional courses, teaching practice and extracurricular activities. Compulsory courses are Ideological and Political Education, Pedagogy, Foreign Language, Physical Education, and Major Courses. The Pedagogy Course consists of Psychology, Theories of Education, Methodology of Subject Teaching, and Teaching Practices. Subjects included in chemistry majors are Physical Chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and others which are the same as in Korea (Zhou, 2000). Comparing curriculum for Chinese Normal University with that of Korean College of Education, the following differences are identified (Lee, K., 2001).

• Ideological and political education is important and compulsory in China, but they are elective subjects for general education in Korea.

• Foreign language (which means English at present) is almost required in both countries, but Physical Education is a required subject only in China.

• In Korea, pedagogy subjects are divided into many subjects such as Educational Psychology, Curriculum and Evaluation, Science Education, Teaching Methods and so on, but they are combined in a few subjects in China.

• Labour, military training, and social survey are obligatory in China, but not in Korea.

Graduates of normal universities with chemistry teacher certificates can obtain teaching jobs without any difficulties in China. But in Korea, graduates with chemistry teacher certificate must pass the teacher recruiting examination of the Provincial Office of Education. Contrary to some western countries, which suffer from a shortage of science

teachers, there are plenty of chemistry certificate holders preparing for their recruiting examinations.

3. In-service training of chemistry teachers

In-service training of school teachers in China is divided into degree and non-degree education. Degree education includes not only make-up education for teachers without qualified certificates but also upgrading education for teachers with qualified certificates. Non-degree education for in-service teachers is the main part of continuing education (CERNET, 2000). On the other hand, in-service degree education is very limited in Korea as all chemistry teachers hold a teacher certificate and at least a Bachelor degree. The Korea National University of Education provides graduate degree programs to small number of teachers selected by the Provincial Offices of Education.

Depending on the purpose and level of training, in-service teacher training can be classified into four types in China (Koo, 1997).

(1) Basic subject knowledge, teaching contents, and principles and methods of instruction is taught to teachers without teacher certificates.
(2) Upgrade education is provided to supplement capability of teachers who hold certificate but are not qualified.
(3) New knowledge and modern theories of education are taught to qualified teachers in order to promote their skills of instructional planning.
(4) In order to produce teacher trainers and key teachers who design school curriculum, educational theory is taught to the selected able and competent teachers.

Probation for new teachers is another form of in-service training in China, but there is no probation system for the newly employed teacher in Korea.

In Korea, in-service teacher training is divided into general in-service training and certificate upgrading in-service training. General in-service training is to supplements teachers' knowledges and enhances teaching skills such as use of computers and the Internet in school chemistry education. Also, large-scale in-service training is organized when national curricula are revised. For example, all high school science teachers had to take in-service training when a new subject called Common Science was introduced in the first grade of high school.

In Korea, after several years of teaching, teachers usually take a long-term in-service training to get a higher level certificate or to be promoted, usually during summer and winter vacations. A teacher who is going to be Vice Principal, Principal, or an inspector for the Office of Education or the Ministry of Education must complete a specific in-service program. The higher level certificate can also be obtained by completing a graduate program of the Graduate School of Education. One more certificate related in-service

training is training of redundant teachers. Many redundant teachers take specially designed 180-hours in-service programs to get additional teacher certificates in different subjects.

Various methods of training are used for the in-service teacher training. In China, broadcasting, TV programs, and even self-directed learning are used. The Internet is a new powerful tool of in-service teacher training in Korea, and about one hundred in-service cyber teacher education programs were registered to the Ministry of Education by the end of May, 2001. About 17,750 teachers were taking the cyber training programs (Lee, K., 2001).

4. Recent developments and issues in chemistry teacher education

Reforming teacher education institutions to enable them to face the 21st century with improved training quality is one of the key tasks of educational reform in Korea and China. The goal of this reform is to upgrade teachers' professional competence by redesigning training models, contents and measures.

In China, "The 5th National Meeting of Teacher Education" held in 1996 pointed out that teacher education should be regarded as the strategic priority for the development of education. Governments at all levels must consider teacher education as a great undertaking that will be beneficial for society and future generations for centuries to come. The immediate targets of teacher education in China are to form a modern and new education system with life-long learning concepts, to aim at fostering new type of teachers who are creative and have practical skills to fit the needs of the 21st century, and to establish a continuing education system for training of all staff in order to upgrade their professional competence.

The size of teacher education at tertiary level has been actively expanded and that of secondary teacher education has been cut down steadily in China. The government boost the merger of in-service teacher training institutes with local teacher training colleges to increase the teaching quality and cost-effectiveness. The quality of teaching and the academic competence of faculty members in the teacher training institutions have been improved through deepening reform. In addition, many achievements in scientific research especially in educational research are accomplished.

In 1995 the Chinese State Council promulgated Regulations on Teachers Qualification, in which the standards for recruiting teachers are strictly regulated and teachers must have certificates before taking their jobs (CERNET, 2000). In China, university graduates without teaching certificates were formerly recruited as chemistry teacher (Luo, 2001).

In Korea, the shortage of primary teachers and surplus of secondary teachers is a big social issue and problem. Many secondary teacher certificate holders re-enter the University of Education to get a primary teacher certificate after two years of training. A Japanese

model of educational reform, merging the University of Education, which trains primary teachers, with the College of Education which trains secondary teachers, has been suggested as a possible solution.

One more serious issue in Korea is the training of secondary "Common Science Teacher". Common Science is the only required science subject in the new seventh national curriculum, and all other science subjects are electives. Therefore, pre-service and in-service training programs for the secondary Common Science Teacher need to be expanded rapidly. But most science teacher educators prefer training physics, chemistry, biology and earth science teachers to training common science teachers. This issue should be examined in connection with the organization of high school science curricula.

V. Conclusion

A country's education system and school curriculum are not only reflections, but pathways of the country's culture. The purpose of this study was to compare secondary school chemistry education in Korea and China, and to find out some meaningful implications for the improvements of chemistry education in Korea. Several issues and ideas derived from the comparisons of chemistry education of both countries are discussed here as the conclusion of the study.

(1) Teaching chemistry as a separate secondary school subject

In Korea, one science subject is taught from the third grade of elementary school to the first grade of high school, but chemistry is taught as a separate subject beginning in basic middle school in China. The Korean science subject is a combined science which includes concepts from physics, chemistry, biology, and earth science. Teaching chemistry as separate subject from the junior secondary subject is a tradition in China and other communist countries, and chemistry is usually taught as a separate subject at senior secondary schools in most countries (DFEE & QCA, 1999). But combined science is an important science subject for the upper secondary schools in Korea and Japan (MESC, 1989; MEXT, 2000). Should we teach chemistry in the middle school, and shouldn't we teach combined science in high school? We need to examined this problem in connection with the overall structure of school curricula and the teacher training system.

(2) Tentative implementation of the curriculum

In China, new curricula are applied nationwide after tentative implementation in a few provinces. In Korea, the third curriculum was tentatively implemented for two years, but since then this process has been skipped because of the unified national university entrance examination. Development of new curricula based on a tentative implementation would be

more effective. The necessity and possibility of gradual implementation of newly developed curricula should be studied more.

(3) Requirement of high school chemistry

Should all high school students learn chemistry as a required subject? The answer to this question is hard to find, but at least one year of chemistry as a required subject is the general trend. In China, chemistry is divided into required and elective courses. Chemistry has been a required subject at least for students in science track in Korea, but it is an elective subject in the seventh curriculum. Chemistry forms a part of "Science 10" in the first grade of high school, but it cannot be regarded as a proper chemistry subject. Considering the influence of chemistry on everyday life and scientific technology, we have to find a way to make all students study chemistry as in China.

(4) Chemistry in the sequence of secondary science

In China. more biology is taught than physics or chemistry in basic middle school, but physics and chemistry are taught more than biology in the advanced middle schools. The idea of teaching more biology and earth science in middle school, and teaching more physics and chemistry in high school has been an unfulfilled dream of the Korean science education community. Because of the territorialism of the physicists, chemists, biologists and earth scientists, concepts of four science subjects are evenly distributed for all grades up to the first year of high school..

(5) Specification of the curriculum

One idea from the Chinese curriculum that should be introduced into Korean curricula is the idea of levels for teaching requirements of concepts. In the Chinese chemistry curricular standards, four levels of teaching (A, B, C, D) are assigned to each teaching concept. A level is awareness stage and B, C, and D are similar to knowledge, understanding and application categories of Bloom's taxonomy of educational objectives (Bloom, 1956). The levels are used as a criteria for planning of teaching and evaluation of each content. Perhaps we should compare the advantages of the Chinese levels for teaching with the more specific attainment targets of the science curriculum in the National Curriculum of England (DFEE & QCA, 1999).

(6) Evaluation of students by oral tests

Evaluation of students by oral test is popular in China. Oral test is a common evaluation method in all communist countries including China, and it is widely used not only for assessment of achievements, but also for school entrance examinations. The grades for the oral test are very good, good, fair, and unsatisfactory (Zhou, 2000). In Korea, the oral test

is rarely used due to the issues and problems related with objectivity and reliability. But the need for oral tests is increasing because it is becoming more important in university entrance examinations. Study of use of the oral test in China would be helpful to improve oral tests in Korea..

(7) Probation system for the new teachers

There is a probation system for new teachers in China. Because of the short length of teaching practice in Korean teacher education, introduction of a probation system has been discussed. The probation system in China, as well as the western system, should be reviewed to introduce the system in Korea.

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