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4. PERSONAL REFLECTION ON THE EVOLUTION OF SECONDARY SCHOOL THEORIES IN CHEMISTRY TEACHING AND LEARNING IN CHINA

INTRODUCTION

In this chapter, the author reflects upon the development of *Theories in Chemistry Teaching and Learning* (TCTL), a subject of teaching and research in secondary school[3] chemistry in teachers' colleges and normal universities[4] in China. Although it is a personal account, because of the unique position, the author has been involved in most of the milestone events in Chinese chemistry education since the 1950s. The chapter thus provides a historical account of how TCTL evolved in the sociocultural environment in China. It becomes an important reference for scholars who want to understand Chinese secondary school chemistry education and research. Besides the important references cited here, an attempt is made to also "standardize" some of the terms for future papers introducing Chinese chemistry education.

There have been several important publications tracking the history of chemistry education in China from 1865 to 1940. For example, Professor Anbang Dai who was a famous inorganic chemist and educator summarized the development of modern chemistry education at the pre-college and university levels in China (Dai, 1945). Two later publications reviewed these changes at the same levels—*Fifty years of chemistry in China* (Editorial Board of Fifty-year Chemistry in China, 1985) and *Sixty years of Chemistry Education in China* (Hua & Liu, 1992). We can situate the evolution of the secondary school TCTL in that context. [The above mentioned publications are not specific to K-12 schools but concentrate on chemistry education in higher education.] As a field, what is the status of TCTL? What are the lessons learned from the past 50 years? What are the issues that need to be addressed and improved now? History is a mirror of reality. This chapter is based on my personal experience when involved in the development of the field of TCTL in China. It is timely to reflect upon the TCTL in Chinese teachers' universities over the past 50 years.[5] This five-decade experience is divided into three periods. I describe the history of this field and suggest implications for further work.

THE EARLY STAGES OF THE CHINESE TCTL CURRICULUM (BEFORE 1960s)

Although education in the People's Republic of China (PRC) had stepped into a new era after 1949, during this period, the schedule and content of TCTL as a curriculum in teachers' colleges and normal universities and as a research area was

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still not mature. Influenced by the curriculum arrangement during the 1930-1940s, the framework, the teaching content, as well as the textbook of TCTL needed to be revised. [In 1932, the course *Secondary School Chemistry Teaching Materials and Methods* (SSCTMM) was firstly opened in Beijing Teachers' College, the former name of Beijing Normal University (BNU). The new knowledge of chemistry, the study of teaching materials and methods and research on chemistry experiments and instruments were the main content of SSCTMM.]

In the early days after the founding of the new China, the subject matter of the TCTL curriculum and its teaching activities had changed little compared to those in old China. As I remember, when I was a third-year undergraduate student in BNU in 1951, one teacher named Tingjun Li taught us the SSCTMM. He was a former teacher in a secondary school in Beijing. There was no designated textbook of SSCTMM except for a printed *Lecture Notes on the Management of Chemistry Lab*. After finishing the course, we were sent to primary or secondary schools affiliated to BNU for the practicum. During my practicum, I taught double-digit division for grade 5 students in the BNU affiliated primary school. I also taught saturated brine (saltwater) electrolysis of chlor-alkali industry in junior high school departments in the BNU affiliated high school and metal elements in senior high school department of the BNU Affiliated Girls High School. The purpose was to allow us to have real experiences and knowledge of teaching process. The practicum allowed us to understand the general requirements and nature of chemistry teaching. Our main task was to read textbooks to become familiar with teaching contents and then develop lesson plans and prepare for experiments step by step before class. We did not feel anxious about the practicum, everything went well. At that time, articles about chemistry textbooks and teaching methods in secondary schools were published in a special column called the *Secondary School Chemistry Teaching* (produced by chemistry department of BNU) of the *Chinese Journal of Chemistry* (*Huaxue Tongbao*). This journal was sponsored by the Chinese Chemical Society (CCS) (http://www.ccs.ac.cn). The journal was kept in the reference room of the chemistry department. The journal was handy if anyone had some doubts on chemistry teaching, he or she would refer to it. My general impression was that researchers of various subjects in BNU studied teaching problems in secondary schools from their own specialty areas. Teachers of our subject only took care of issues on secondary school chemistry textbooks and teaching methods. Theories of chemistry teaching were not emphasized. Therefore it was difficult to find articles discussing chemistry teaching at the theoretical level in the *Chinese Journal of Chemistry*.

It should be mentioned that chemistry textbooks for basic education [K-12] had to follow guidelines from the national syllabus during that time. Because the Chinese Ministry of Education (MoE) declared that teaching schedules and the syllabus were legal documents of the state, they were thus the national standards. [In China, the MoE is responsible for implementing the relevant education legislation, regulations, guidelines and policy documents, for planning the development of the education sector, and for integrating and coordinating educational initiatives and programs nationwide.] The teaching schedules and

syllabus were developed by MoE, so scholars had few opportunities to criticize or disagree with the syllabus and teaching schedules. Instead, they could only explain or provide instructions of those documents in order to assist chemistry teachers. My articles during the late 1950s and early 1960s were such cases and they were titled *Discussions on the Task and Content of Chemistry Teaching in Secondary Schools* (Liu, 1962a), *Strengthening Teaching and Learning of Fundamental Concepts of Chemistry* (Liu, 1962b), and *Improving Instruction on Chemistry Experiments to Enhance Chemistry Teaching* (Liu, 1964). I was only able to express my disagreement in my articles in a less direct manner in that situation. For example, my comments on the levels of teaching requirements and their internal relationships in *The Main Tasks of Chemistry Teaching of Secondary Schools* (Liu, 1962c) were quite different from the instructions given by the *Chemistry Syllabus for Secondary schools* in 1956.

The development of the TCTL curriculum as a subject had also been constrained by the curriculum program, faculty, textbooks, equipments, and pilot schools. Even the name of the subject was not consistent. There were course names such as *Secondary School Chemistry Teaching Materials and Methods*, *Methods of Chemistry Teaching of Secondary Schools* or *Chemistry Teaching Methods*. In fact, the naming of the chemistry education and research area and its framework were heavily influenced by the former Soviet Union. For example, plenty of lengthy and tedious translated papers originally in the *Russian Journal of Chemistry in School* were published in the *Huaxue Tongbao*. Names of some famous Russian scholars of chemistry education frequently appeared in *Huaxue Tongbao*, such as Cvjetkov, Jegorkin, Boros, Glinkal, Rubinstein, and Popov. Works of Shishkin, Borisov, Shapovalenko became the designated references for students' learning theories of chemistry education.

In China, the content and structure of the newly published chemistry textbooks in secondary school in the 1950s and 1960s were mainly translated from the textbooks of the former Soviet Union. For this reason, stories of chemists like Lomonosov, Mikhail Vasilievich, Mendeleev, Dmitry Ivanovich Butlerov, Alexander Mikhailovich and Madame Curie became the typical models for students' education in patriotism and internationalism. Western scientists such as Dalton, Boyle, Lavoisier, and Ramsay were rarely mentioned in class. In my chemistry teaching methods courses, our discussion on chemistry teaching in secondary schools was in closely connected to interpreting the syllabus and analyzing the content of chemistry textbooks.[6] Chemistry education faculty always gave students advice on teaching methods according to the steps in the teaching process and they encouraged their students to get experience from teaching practice. Because the analyses of textbooks and methods of teaching was arranged before student teachers went to schools for practicum, they had difficulties in understanding the organization and design of instruction at this theoretical level. The representative textbook was the *Lecture Notes on Chemistry Teaching Methods* (Chemistry Teaching and Research Program, 1958) during this period. The book consisted of three parts including general theories, specified theories of teaching individual topics, and chemistry experiments. It was produced by the

chemistry department of BNU under the guidance of the *Experimental Syllabus of Chemistry Teaching Methods of Chemistry Department of Beijing Normal University* issued by MoE in 1955.[7]

Practice makes a good teacher. In order to find the best way to prepare future chemistry teachers, the faculty of the Secondary School Chemistry Teaching and Research Program (SSCTRP) from the chemistry department of BNU including myself all went to our affiliated schools as adjunct chemistry teachers in the beginning of 1960s. We had to change the way we taught the chemistry teaching method courses. We did not think mimicking the former Soviet Union or learning how to teach based on student teachers' own reflection of their learning experience would work well. We needed to develop our own theories of chemistry teaching and learning. During the early 1960s, three of us (Mr. Shaohua He, Ms. Naihong Yao and I) taught as chemistry adjunct teachers in the BNU affiliated boys' and girls' school. In order to develop the TCTL curriculum for pre-service chemistry teachers, I taught junior high school chemistry in the BNU affiliated secondary school from 1953 to 1955 in order to gain firsthand experience. The time I had was too brief to obtain much experience though.

THE DEVELOPMENT STAGE (1970s-1980s)

After reflecting on several "Education Revolution" movements and our own teaching and research experiences in 1959, as the director of the Inorganic Chemistry Teaching and Research Program of BNU (The SSCTRP had been removed during Cultural Revolution which lasted 10 years from 1966 to 1976), I took charge of the development of the *Nine-year Schooling Chemistry Textbooks* (Volumes 1-4) (Reform Team of General Education, 1960) and the work of General Education Reform Committee (GERC) in the Chemistry Department of BNU. The other two authors of this textbook were Mr. Shaohua He and Ms. Naihong Yao, both of them were members of GERC. We tried to develop some theories in chemistry teaching and learning according to our own practice and then test these theories in practice again. Since 1978, Mr. He left for the People's Education Press (PEP) to develop chemistry textbooks for secondary schools. This collaborative relationship to connect TCTL to the development of chemistry textbooks lasted until at the end of 20th century.

In the summer of 1980, the *Teaching Plan of Chemistry Department of Normal Universities* revised by MoE was implemented. The plan brought order out of chaos in teaching in normal universities after the Cultural Revolution in China. However, it also brought disastrous side effects. The subject title was assigned as *Secondary School Chemistry Teaching Materials and Methods* (SSCTMM). There were a total of 48 periods with eight periods a week of lectures! This was after the student teachers completed chemistry content courses. It took student teachers six weeks of cramming the course content right before their teaching practicum. According to this plan, the Chinese MoE planned to publish *Secondary School Chemistry Teaching Materials and Methods Syllabus in Chemistry Department of Normal Universities* in 1980. [The syllabus was drafted by Lanfen Wang, who was

from Southwest Normal University. Other co-authors were Zhixin Liu, Jiayin Li, Huishu Liang, Xitong Wang. They were faculty members of BNU, East China Normal University, Northeast Normal University, and Hebei Teachers' College, respectively]. Experts and teachers were asked to produce new textbooks, restart the course, and carry out teaching activities in normal universities and teachers' colleges following the syllabus. Because the MoE chemistry teaching method course syllabus was not practical in terms of when to teach the course and when to arrange student teacher practicum, the document later was used just to provide guidelines instead of being strictly followed. Universities were allowed to make their own arrangements for chemistry teaching method courses according to their local situations. However, the curriculum framework and the number of periods assigned to the subject were not able to deviate very much.

Since 1982, as the pioneers, three normal universities that reported directly to the Chinese MoE started to recruit master's level students in the field of chemistry education. These universities were East China Normal University, Northeast Normal University, and Beijing Normal University [These universities were also called MoE-administrated Universities in China for the presidents of these universities are appointed by the Chinese MoE]. This had greatly promoted the development K-12 Research and Practices in Chemistry Teaching and Learning! However, the specialty area assigned by the Academic Degrees Committee of the State Council was still the *Research on Secondary School Teaching Materials and Methods*. This was the consequence made by former teaching plan (*Teaching Plan of Chemistry Department of Normal University*, MoE, 1980). [The great limitation of this designation was that this research area was not considered as equal to some other areas in educational research such as general education theories and curriculum. Instead, this multidisciplinary area has been put in a situation to be subordinate to chemistry and general education theories.]

With the support of the head of the chemistry department of BNU, two courses were started in the third year for undergraduate students: *Chemistry Teaching Methods* (2 periods per week) and *Study of Secondary School Chemistry Experiments* (3 periods per week) for a semester, respectively. The purpose was to (a) train students to conduct chemistry experiments following standards, and (b) develop their competence in using and revising chemistry experiments for teaching. There were limited lecture and time for developing lesson plans and micro-teaching practice. The change of the program was to develop student teachers' basic competence for teaching chemistry in secondary schools. How tough the working conditions were! There was a shortage of faculty in chemistry education program and appropriate textbooks. Nevertheless, we tried our best to work hard in order to prepare chemistry teachers to teach the new secondary school curriculum.

I followed the call from BNU in 1978 and came back to resume the SSCTRP. There were three faculty members in SSCTRP initially. Mr. He had been called to work at the PEP to develop secondary school chemistry teaching materials. The other two were Ms. Yao and myself. I was responsible for developing the lecture plans called *Chemistry Teaching Methods* while Yao took charge of developing

lecture plans for the *Study of Secondary School Chemistry Experiments*. With concrete experience from short term training courses for chemistry teachers held at eight suburban counties in the north area of Beijing between 1973 and 1978, I understood better teachers' teaching abilities and their weakness. Therefore, the design of the two courses was more relevant and realistic in practice. After two cycles of implementation, the lecture notes of the *Chemistry Teaching Methods* were submitted for publication in October 1981. The series title was named *Teaching Materials and Methods* so that we had to change the title of the textbook, as did other subjects (e.g., physics, biology) (Liu, 1983a).

It should be noted that two events had contributed significantly to the development of the field of TCTL. One was the *First National Normal University Colloquium of Secondary School Chemistry Teaching Materials and Methods* from May 25 to June 1 of 1983 in Shaanxi Normal University in Xian. The other was the establishment of the *Secondary School Chemistry Teaching Materials and Methods Examination and Approval Team* under the MoE *Higher Education Institutes' Science Teaching Materials Examination and Approval Committee* in 1985. There were 67 representatives and 46 more participants from more than 80 universities and colleges in China who attended the conference in Xian. Seventy-eight conference papers were received in total. In this conference, the status and functions of *Secondary School Chemistry Teaching Materials and Methods* curriculum was clarified among teachers' universities and colleges. The characteristics of the curriculum as being thoughtful, demonstrative, and practical as well as the importance of educational and scientific research were emphasized in this conference. I wrote a paper for the Xian conference: *My Reflections for the Development of Chemistry Education* (Liu, 1985a) to provide a brief description and comment on the formation and development of Chinese chemistry education theories. According to the missions of teachers' colleges and normal universities, I made suggestions on reforming the course *Secondary School Chemistry Teaching Materials and Methods* and the key research areas in Chinese chemistry education. In my opinion, it was necessary to take reform efforts in the development of curriculum and its framework. A new course *Study of Chemistry Education* could be the complement of the *Teaching materials and methods* course. Another curriculum *Chemistry Education Introduction* was introduced to graduate students and teachers for further study. The establishment of these courses was good for our subject development. It stimulated deeper thinking of scholars and faculty of chemistry education that the subject framework should be improved with a view of integrity, comprehensibility, and specialty. The *Study of Secondary School Chemistry Experiments* was proposed for undergraduate students in the paper above. The topic of this curriculum was the study of classic experiments of secondary schools. It emphasized training students' standard operation of experiments and improving their ability of designing new experiments for teacher purposes after learning secondary schools chemistry experiments. Our five-year teaching practice had proved that the arrangement of the three courses was effective (Liu, 1985a). In 1984, the Subject Development Task Force[8] of *Secondary School Chemistry Teaching Materials and Methods* was grouped by *Higher Education Institutes'*

S*cience Teaching Materials Examination and Approval Committee* under MoE. The task force's responsibilities included the designing, writing, and editing textbooks in the area of chemistry teacher education in teachers' colleges and normal universities. It made great contributions to TCTL development.

From many years of experience teaching and doing research in chemistry education, I felt strongly that we could not simply follow the national secondary school chemistry syllabi to conduct research on chemistry teaching materials and methods. [In China, the MoE issues the national chemistry curriculum syllabus. The Textbook Committee of MoE designates the People's Education Press (PEP), which is the biggest and most authoritative textbook publisher in China, to develop secondary school chemistry syllabi and textbooks and other teaching materials, including teachers' guide books. The textbooks published by PEP were called national unified textbooks and teaching materials. There was only one set of secondary school chemistry teaching materials developed by PEP until the new curriculum reform in 2001. From 1986 onward, the PEP was not designated by MoE as the only legitimate curriculum developer. Different institutions, such as universities, bid for grants for developing curriculum standards of different subjects at K-12 level. For example, the junior high and high school chemistry curriculum standards were awarded to a team led by members from Beijing Normal University and East China Normal University. The Jiangsu Education Press and the Shandong Science and Technology Publishing House also became the new chemistry textbook and teaching material publishers]. We would be constrained to only study the chemistry textbooks according to its structure, content system, and suggestions for teaching methods in a general, subordinate, and explanatory manner. It led to superficial and common sense research without being able to take into account of the evolving nature of chemistry as a field and learners' motivation, learning difficulties, and ways of learning. When the structure and organization of chemistry textbooks changed, we should be able to articulate why it was changed and how to respond to the changes in order to teach well. If we analyzed textbooks in the traditional way described above, we might be able to make our statements consistent, which was both the old and new textbooks were appropriate, but the only contradicting conclusion we could draw was that the structures of former textbooks and new textbooks were both reasonable. We would be in an awkward situation. For example, one set of textbooks might use a sequence of Periodic table, Atom, Molecules for a chemistry text while another set of chemistry textbook might have a sequence of Atom, Periodic table, Molecules. The former set of textbook argues knowing the nature of things from their rational knowledge to perceptual ones. The later set of textbook might argue that deeper understanding of the theories and laws of chemistry helps understanding of chemistry. Both arrangement and explanation can be only opinions if there was no educational research data or theory to support the claims with specification of the context.

Challenging questions in both theory and practice urged us to realize that if we did not analyze problems in chemistry textbooks and chemistry teaching from epistemological and methodological approaches, we would not be able to rise above and be flexible in providing solutions to practical challenges. And we also

needed to solve these problems in accordance with how students develop cognitively and how students learn chemistry. There had been a series of papers by senior scholars. They told us how to deal with problems in chemistry education, such as *Developing Students' Ability in Chemistry Teaching Should Follow Natural Science Methodology* (Chen, 1980), *Comments on Modern Elicitation Methods of Teaching* (Li, 1981). Many theories incorporating teaching practices were stated in these papers. In short, we should solve teaching problems based on practice. We should make our effects to develop generalized claims about how students learn chemistry and decide our research questions and methods based on the papers. In my paper *Brief Discussions on the Content and Style of Chemistry Experiments in Secondary Schools* (Liu, 1979) and my book *Secondary school Chemistry Teaching Materials and Methods* (Liu, 1983b), I had stated the following suggestions: For students in teachers' colleges and normal universities who have never taught in secondary schools, the focus of teaching might be helping them understand some questions in theory about teaching methods after taking the *Chemistry Teaching Methods* course. They should get familiar with the chemistry teaching principles and will be able to understand the trends of chemistry teaching methods through applying theories in their practice. They should be good at making teaching plans, giving lectures, and developing other basic teaching competences on their own. For those student teachers who have been teaching in secondary schools for several years, this course should inspire them on how to generalize some general teaching principles and open up their minds on educational research. On one hand, undergraduate students were called on to hold correct views and learn important teaching methods. They should collect some positive or negative cases which were typical in our daily class. On the other hand, they should be aware of educational news at home and abroad. Finally, educational research had to be based on teaching practice (Liu, 1983b). My other paper *Comments on the Objectives and Curriculum Design in Chemistry Education* (Liu, 1986a) was also the result of my teaching, research, and reflection in chemistry education.

During the period of 1980s, academic research on chemistry education flourished. *The Chinese Journal of Chemical Education (CJCE)* sponsored by CCS started in April 1980. [The *CJCE* is one of the core journals of chemistry teaching and learning theories in China at present]. Symposiums on chemistry teaching in secondary schools and teachers' universities were held by the Chemical Education Committee (CEdC) and Division of Chemistry Teaching (DCT). They were affiliated to the CCS and the Chinese Education Society (CES). These events yielded substantial results. In 1986, the State Education Commission (SEdC) recommended that there should be more varieties of elementary and secondary school curriculum and teaching materials as long as they satisfied the basic requirements specified by MoE (in national syllabi). This greatly stimulated curriculum reform and the development of textbooks and teaching materials for elementary and secondary schools. In 1983, staffs in the Teaching and Research Section of Shandong Province together with teachers of BNU developed chemistry teaching materials (textbooks) for 5+4 schools (5 years of elementary school plus

4 years of junior high school). The curriculum was implemented in pilot schools in Shandong, Sha city of Hubei, Heilongjiang, and Hebei province. The experimental classes received good grades in examinations. I was the chief editor and later Mr. He served as the chief editor of the first and second volumes of the textbooks (Liu & He, 2002). In 1987, this set of textbooks was one of the recommended national textbooks by SEdC. Later, the textbooks were approved by the State Secondary and Primary School Textbooks Examination and Approval Committee as recommended textbooks across China and could be selected by various provinces, municipalities, and autonomous regions for their use. Chemistry teaching and learning research flourished during that time! The changes at K-12 levels also stimulated reform in teachers' colleges and normal universities. So this was the high point in our field.

I was honored to be one of founders of *CJCE*. I had also taken charge of academic activities of two organizations (CCS & CES).[9] In order to serve members, we had to learn quickly from others and our own practice. We had to provide solutions to real world problems. The situation forced us to declare our stand on issues in the field. Many representative papers were published for dealing with issues in the field of TCTL. For example, these were the papers I wrote in response to issues in the field: *Comments on Teaching Methods of Chemistry Language* (Liu, 1980), *Enhance the Teaching of Chemistry Experiments and Fostering Student Ability in Chemistry Experiments* (Liu, 1981a), *Choose Quality Chemistry Exercises and Develop Student Ability in Self–Learning and Independent Work* (Liu, 1981b), *Preliminary Research on Teaching Models in Chemistry Classroom* (Liu,1982), *Reform Teaching Methods and Inform Teaching Research in New Ways* (Liu, 1984), *How to Understand the Characteristics of Chemistry Teaching* (Liu, 1985b), *Fully Understand the Methodological System Of Chemistry Teaching* (Liu, 1986b), *On Heuristic Approach in Chemistry Teaching* (Liu, 1987), *General Principles and Methods of Chemistry Teaching in Junior High Schools* (Wu, Liu & Liang, 1988a), *Characters, General Principles, and Methods of Chemistry Teaching in Senior High Schools* (Wu, Liu & Liang, 1988b). The papers were intended to summarize and generalize some theories based on papers about chemistry education practices. Supported by experts of the Editorial Board of *CJCE* and authors, we stuck to our guiding principles and chose articles that reflected the development of chemistry education when editing *CJCE*. Meanwhile, some columns were used to be a bridge between the readers, writers, and us. For example, we had the following columns: *For Readers and Authors*, *Greetings and Announcements*, *Words of Editors*, *New Year Greetings*, *Heritance·Practice·Innovation*, *Pioneering and Innovation·Unite and Contribute* (1980-2005). These columns were the best platform for our further communication with readers. When working for CES and DCT, some experts in the field and I made plans of educational research and academic exchange in order to create an open and relaxed discussion environment to meet the needs of chemistry education development for members. At that time, I tried my best to exchange my views of chemistry education with other colleagues, they could be found in my papers, opening speeches, and closing speeches in all previous congress of CES (Liu, 1993b,

1997b, 1997c, 2002b, 2004b). My ideas about solving problems in practice were included in the preface of my book *Chemistry Didactics (first edition)*. It was completed on August 1, 1989 and was published by Higher Education Press in 1990. The idea was elaborated in the preface of my book: The development and improvement of this curriculum (CTCL) depends on the theoretical generalization and the precious experience of chemistry teachers. On one hand, all practicing chemistry teachers should contribute their own valuable experience to the development of chemistry education theory. On the other hand, teachers need to find ideas from requirements for subjects of chemistry in contemporary teachers' universities. It can improve their teaching ability and open their minds. In order to have good performance in their teaching, they also have to explore principles and laws of chemistry teaching. It was said, for students of chemistry education and chemistry teachers, this curriculum played a special part in chemistry education (Liu, 1990).

ON THE RAPID DEVELOPMENT STAGE (AT THE END OF 20TH CENTURY TO PRESENT)

The *(Nine-year) Compulsory Education Law of the People's Republic of China* took effect on April 18, 1986. [It established requirements and deadlines for attaining general education tailored to local conditions and guaranteed school-age children the right to receive at least nine years of education (five-year primary education and four-year secondary education or six-year primary education and three-year secondary education).] Starting from fall 1986, there was a new framework of *One Set of Standards and Multiple Sets of Textbooks and Separation of Textbook Editing and Examination* to guide curriculum development in China. The specialized courses for undergraduate students were the most practical and basic for student teachers in teachers' colleges and normal universities. They are compulsory and required courses. For the graduate curriculum in chemistry education, we had to recognize it being within the chemistry education discipline and try to apply general theories in education and focus on the most important issues in the field. A higher level curriculum was needed for graduate students. When teaching *An introduction to Chemistry Pedagogy* and *Selected Readings on Modern Teaching Theories*, I Completed Papers such as *On Reform of Teaching Chemistry Experiments* (Liu, 1991), *Discussions on the Objectives, Tasks, and Practice of Science Teaching Based on Experience in Chemistry Teaching in Teachers' Colleges and Normal Universities* (Liu, 1993a), *A New Chapter of Enlightening Period of Chemical Education* (Liu, 1992), *Brief Comments on Chemistry Education of Secondary School* (Liu, 1994), *Two Classifications of Overseas Chemistry Teaching Methods* (Liu, 1995), *Teaching Modes of Chemistry Classroom Revisited* (Liu, 1996a), *On Science Education Objectives and Curriculum Development* (Liu, 1997a), *Comments on Chemistry Education and Scientific Literacy* (Liu,1999a) and so on. They were all outcomes of my theories in chemistry education in 1990s. In order to summarize the special characteristics of chemistry teachers, especially the special-grade[10] teachers who dedicated

themselves to chemistry education, I edited two books to reflect their dedication to chemistry education. One book is titled *The Teaching Beliefs and Practice of Chinese Famous Special-Grade Teachers* (*secondary school chemistry volume*) (Liu, 1996b) and the other is titled *Lecture Notes of Expert Teachers* (*secondary school chemistry volume*) (Liu & Sun, 1997). The books included cases of how some expert chemistry teachers conducted lessons and why they conducted their lessons in certain ways. They also provided more information about how chemistry teachers could grow to be outstanding teachers.

In 1996, the Academic Degree Committee of the State Council (ADCSC) issued a *Notice of Pilot Projects in Master's of Education*. [ADCSC was the administrative authority for academic degrees in China-Bachelor's, Master's and Doctoral degrees). Sixteen normal universities started their master degree in chemistry education programs according to the document. I wrote an article *Comments on Preparation of Students for Master's Degrees in Chemistry Education* (Liu, 1999b). In this article, I proposed goals and suggestions on full-time and in-service teacher master's degree programs in chemistry education. The paper addressed the *Curriculum Goals and Schedule*, *Teaching Modes and Assessments*, *Dissertations and Degree-Awards* regarding graduate education in chemistry education. In the summer of 2001, I wrote another article *On the Education of Master's Students in Chemistry Education Again* (Liu, 2001a) based on our experiences in graduate education in chemistry education. The article addressed the focus and curriculum of the chemistry education graduate program. With the implementation of the 8th curriculum reform of basic education in China, I published the following papers to exchange my ideas with colleagues: *Comments on Changing Beliefs of Curriculum* (Liu, 2001b), *The Realization of Learning Chemistry Program Standards* (Liu, 2002a), *On the Integration of Content and Process Learning Objectives* (Liu, 2003a) and some other articles stating my reflections on Chinese chemistry education at that time.

During the early years of the 21st century, several normal universities were given permission to establish PhD programs in Chemistry Education. They were Nanjing Normal University, East China Normal University, Northeast Normal University, Beijing Normal University, and Shanghai Normal University. This provided great momentum for the development of the field of chemistry education. As a senior scholar in the field of chemistry education, I was always concerned about the development of this field at the policy level. Therefore, I wrote the following papers to share my opinions with other colleagues in the field, such as *On Issues About the Teaching Material Development of TCTL* (Liu, 2003b), *Retrospection and Reflection of the Development of TCTL* (Liu, 2003c), and *Issues on the TCTL Curriculum Reform in China* (Liu, 2005).

In my opinion, over the past 20 to 30 years, following the trends in science education and curriculum development theories, besides being more academic, the basic education curriculum is emphasizing more on the relationship between chemistry and society, the interaction between chemistry and technology and society, and how to guide students to understand social issues and solve social problems. The purpose is to let students understand society, solve social issues, and

attain the integration of science literacy and art literacy. In this basic education reform, textbook development should reflect "student-centered" principles. The development should focus on big ideas in the field and make concrete steps to implement them. We should modernize the course content, change how we present course content, foster self-regulated learning, help students understand their learning processes, and motivate student learning through assessment. Therefore, curriculum in the field of chemistry education also needs reform. My paper *Issues on the TCTL Curriculum Reform* (Liu, 2005) answers some of the urgent questions mentioned above.

Since October 1949 to November 1998 when the SEdC held a conference on evaluating and approving the basic requirements for undergraduate chemistry in teachers' colleges and normal universities in Beijing, experts in the field of chemistry education had been frustrated by the fact that the name of our field[11] was not clear, confusing, and not conducive for international dialog. Although we had tried to come to a consensus during the *National Symposium on the Development of Science Teaching and Learning Methods of Normal Universities* in October 1986 in Shandong Normal University (Jinan City), we were not totally successful. During this conference, representatives from all over China had reached a common ground on an initiative that the *Subject (chemistry) Pedagogy* should be established for subject development, graduate student preparation, teacher education, and international exchange. Notes of the meeting were submitted to Academic Degrees Committee Office of the State Council. Unfortunately, our proposal for establishing the field of *Subject Pedagogy*[12] did not get approval. The committee only accepted the *Theory of Subject Teaching and Learning* as the specialty for graduate students. This name proposed by this paper *Theory of Chemistry Teaching and Learning (chemistry didactics)* seems to be more appropriate to replace *Secondary School Chemistry Teaching Materials and Methods*. Consequently, there were two textbooks *Chemistry Didactics* and *Study of Chemistry Experimental Teaching*[13] (Liu, 1990). The syllabi of two curricula were based on the results of a symposium with scholars in the field of chemistry education who were selected by the *Secondary School Chemistry Teaching Materials and Methods Examination and Approval Team* under *Higher Educational Institutions Science Textbook Examination and Approval Committee of MoE*. Then two textbooks were published by China Higher Education Press (CHEP) for teachers' colleges and normal universities in 1990 as soon as the author team for developing textbooks was formed. My wish to rectify our subject's name had also accomplished. In the late 1980s, *the Program of Theory of Chemistry Teaching and Learning Curriculum Reform* was issued by SSCTRP of chemistry department of BNU as an effort to deepen the curriculum reform in many universities. After finishing the two compulsory courses, student teachers were required to go to secondary schools for teaching practicum. After practicum, they needed to take two optional courses, one was *Measurement and Evaluation of Chemistry Teaching*, another one was the *Literature on Chemistry Learning Psychology*. Similar reform of curriculum in chemistry education also happened in Northeast Normal University. There was another compulsory course named the *Analysis of Textbooks*

and Microteaching of Chemistry besides the two compulsory courses mentioned above. They also added two elective courses: the *Literature on Chemistry Teaching* and the *Theories of Moral Education and Practice in Chemistry Teaching* (Liu, 1993b), *Chemistry Didactics (first edition)* was piloted for two years. After receiving the approval from experts who took part in the *Expanded Conference of TCTL Textbooks Development in Secondary School* held by the *Steering Committee of Chemistry Education in Higher Educational Institutions* under the *State Education Commission.*[14] I took charge of the development of *TCTL (second edition)* and it was completed in spring 1955. After stepping into 21st century, the third edition was compiled by young and middle-aged experts of TCTL in March 2000, I was the chief editor. The book was published in 2004, as part of the 21st century textbook series by China Higher Education Press (Liu, 2004a). It was the fruit of the subject development efforts. It not only met the needs of current basic education reform but also summed up the feedback from users of the second edition. This book can be considered as the authors' especially my reflection on the subject development.

After 1990s, with China's open-door policy and reform effort, there had been active exchange and communication of research in the field of chemistry education. As the president of the Board of Directors of DCT, the chief editor of *CJCE*, and a member of the *Secondary School Chemistry Teaching Material Examination and Approval Committee* under the *State Secondary and Primary School Textbooks Examination and Approval Committee*, I had opportunities to lead some academic activities in the field of chemistry education. Based on nearly ten years' continual hard work, reflection, accumulation, and practice in graduate education, I have cleared my mind, widened my vision of academic research, and enriched research areas in chemistry education. The past experience became the foundation of the *Theory of Chemistry Education* series. There were six books in the series. It later became part of the *Theory of Modern Subject Education* series of Guangxi Education Press. I organized a team of specialists to edit this series (Liu & J Wang, 1996; Liu & Z Wang, 1996; Liu, Wu, & Wang, 1996). It was an academic achievement from much teamwork. My reflection and summaries of practice and experience can be found in the introduction of series and the preface and introduction of *Theory of Chemistry Instruction System.*

By 1997, there had been six sets of chemistry teaching materials published as part of series of nine-year compulsory teaching materials in China. There were also six independent sets of chemistry textbooks for national use. All textbooks for obligatory subjects taught in primary and secondary schools have to be examined and approved by the *State Teaching Material Examination and Approval Committee* before publication in terms of the accuracy of content, scientific spirit, and adaptability to classroom instruction in China. The *Third National Education Work Conference* in 1999 and the *Action Plan for Vitalizing Education in 21st Century* by Chinese MoE provided definite guidance for the 8th basic education curriculum reform. A collection of experts in the field of chemistry had made important contributions to this reform. The issue of *Chemistry Syllabus of Full-time Junior High Schools of 9-Year Compulsory Education (revised pilot edition*)

became a prelude to the eighth curriculum reform. The publish of *Chemistry Curriculum Standards of Compulsory Education In Full-Time Schooling System (experimental edition, 2001*) and *Chemistry Curriculum Standards Of General Senior High Schools (experimental edition,* 2003) with many sets of chemistry textbooks used in junior high schools and senior high schools opened up broad prospects to the subject for teachers. Fortunately, I was able to go through the process with young and middle-aged colleagues in the field to learn from colleagues from China and overseas. I tried to put the ideas and requirements of *Outline of Curriculum Reform of Basic Education (trial edition)* into practice to make new exploration.

I have come to understand that no matter what the subjects, their development and formation are restricted by the laws of their scientific development. When a field is born, it will go through a process from practice to theory and gradually elevates and enriches itself. In theory, as a branch of chemistry, chemistry education is different from inorganic chemistry, organic chemistry, and physical chemistry in terms of its tasks, objectives, and characteristics. It is a special system consisting of chemistry teachers and learners that take knowledge of chemistry as its carrier. Chemistry education follows certain beliefs of education and theories about how student learn. There are at least three subsystems of a chemistry education system: The teaching system, learning system, and the feedback system. The chemistry teacher is in the center of a guiding or facilitator system, the learner is the center of a learning system. While taking the knowledge of chemistry as carriers, the chemistry curriculum is the important media which promotes the operation of educational teaching and interaction between chemistry teachers and learners. Chemistry curriculum is in the center of a chemistry education system. Just like a passage, the feedback system ensures the harmonious operation of a chemistry education system, and warrants high quality and efficiency of chemistry education. Any teaching or learning theory (ideas, claims, or propositions) is the results of educational practice. It is the product of historical reflection, which originates from teaching practices and in turn guides practice. It plays an important part in explaining the practice, guiding the practice, and improving the practice. It is my great pleasure to learn, to teach, and tirelessly strive for the advancement of the field of chemistry education.

A curriculum is a collection of things to teach in order to achieve the goals of schooling. In order to develop a curriculum, we need to follow the learning objectives and the available resources for teaching and learning, we need to decide the content, we need to decide how to represent content in a coherent way. We cannot simple put pieces together like a salad. For our modern *Theories of Chemistry Teaching and Learning* as a subject or research area, we need to position the area as part of science education. This is an interdisciplinary area at the intersection of basic education, vocational education, higher education, and adult education. We should conduct classroom-based and school-based research in order to discover the uniqueness of chemistry education. We should study the epistemology and methodology of chemistry education in order to advance the field of chemistry education.

I have been working in the field of chemistry education for more than 50 years. When facing difficulties and challenges in my work or relationship with people, I always use the motto of Beijing Normal University: *Learn to be an excellent teacher; Act as a role model* to encourage myself to face the challenges. I make a great effort to follow motto and the following principles in my work and life: *The primary concern in my life is my career*; *be strict to myself and lenient towards others. Work hard, practice what I preach*; and *Learn from other scholars, and be ready to hand the scholarship down to the next generation*. I have to solve specific issues in light of realities to understand the general problem in our subject. I have been presently writing papers, discussing problems, and sharing my ideas. I keep thinking about how to keep our traditions and foster innovation. I try my best to balance tradition, development, and innovation in my teaching, supervising, and research. I keep my mind open for new perspectives and ideas that can improve teaching and research. It is also a process in continual improving and updating my knowledge of the field. I believe that it is never too old to learn. Since 1970s, I had fewer opportunities to observe classes and go to schools myself. I wish I could have done more work on chemistry teacher education and action research. In conclusion, I sincerely hope that younger scholars can spend more time on chemistry teacher education and action research. They should be creative and innovative in advancing teaching and research in the field of chemistry education. I am sure the golden age of TCTL will come soon!

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NOTES

[1] Professor Zhixin Liu (1928-) spent years to complete the Chinese version of this manuscript and the Chinese version has been published in the *Chinese Journal of Chemical Education* (2008, Volume 29, Issue 11, p. 10–16). This chapter was translated and modified by Ms. Daner Sun and Dr. Baohui Zhang with an intention to match the English counterparts of the Chinese terms (if applicable) and provide background information for international readers who may be unfamiliar with the history of Chinese chemical education. Their editorial revisions or explanations are mostly indicated in "[ ]". The translation of some special terms used the *Oxford English Dictionary*, *English Collocation Dictionary*, *Dictionary of Name Translation of the World*, and *Wikipedia*. Some of these terms, such as *Theories in Chemistry Teaching and* Learning (TCTL), were coined by the translators based on the meanings of Professor Liu's original paper in Chinese. "Chemistry teaching methods" is probably the nearest English equivalent of TCTL.

[2] Corresponding author for this English version is Dr. Baohui Zhang (baohui.zhang@nie.edu.sg).

[3] The period of secondary school refers to students from junior high (grades 6 to 10) and senior high (grades 11 to 12). This is the period after elementary school and before college. Children usually go to secondary school between the ages of 11–14 years, and finish between the ages of 16–18 years. There is variation of ages from country to country.

[4] Teachers' colleges and normal universities specialize or have departments in pre-service teacher education in China. Here, we consider these two institutions as the same. On the other hand, there are increased numbers of non-teaching majors in some teachers' colleges and normal universities while some comprehensive universities are also graduating teaching majors.

[5] For faculty in (junior and senior) high school chemistry education programs (*Huaxue Jiaoxue Fa Jiao Yan Shi*), TCTL is a specialized area. Recently, the programs in some top teachers' colleges and normal universities in China have changed the names and organization structure in Chemistry Education Institutes (*Huaxue Jiaoyu Yanjiu Suo*). On the other hand, at a level of a city or above, a school district in China would have a High School Chemistry Education Research office (*Zhongxue Huaxue Jiaoyan Shi)*, which function to study how to improve chemistry teaching and learning in schools. They also have administrative functions such as organizing local Chemistry Olympiads or examinations at district level or above.

[6] There was only one set of secondary school chemistry teaching materials (including textbooks and teachers' guides) developed by the People's Education Press from 1950s to 1990s.

[7] Some authors were teachers of Hebei Normal College (Beijing), Tianjin Normal College, Shijia Zhuang Normal College (Hebei), the No. 9 Women's Secondary School, the No. 11 Women's Secondary School and the No. 29 Secondary School.

[8] Members of our subject development task force were Zhixin Liu (Director), Huishu Liang, Jie Fan, and Shaohua He (secretary).

[9] I was elected as the member of the 22nd and the 23rd Board of Directors of CCS, the vice director of CEC, member of 4th and 5th Board of Directors of CES and the director of DCT.

[10] In China, to acknowledge some teachers' enormous contribution to education, the government will give them a title of special-grade teachers as a reward.

[11] The name *Secondary School Chemistry Teaching Materials And Methods* (*Zhongxue huaxue jiaocai jiaofa*) was established in summer 1980 by the MoE. The literal meaning is that the main work of this subject is to study the textbooks and the teaching methods of textbooks.

[12] Please note that the change of name affects all subjects at teachers' colleges and normal universities. For example, the physics education field would need to change to *Physics Pedagogy* if our proposal for *Chemistry Pedagogy* was approved.

[13] *Study of Chemistry Experimental Teaching* was edited by Professor Xitong Wang (Wang, 1990).

[14] The State Education Commission of PRC restored its name as the Chinese Ministry of Education after the Fifth Session of the Ninth NPC (the National People's Congress) in March of 1998.

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