# Chapter 17
# An Overview of Professional Preparation for Preservice and In-Service Science Teachers

**Cheng Liu and Enshan Liu**

## 17.1 Introduction

In the past decades, which have featured rapid Chinese economic, social, and educational growth, Chinese students, representing a large source of science and engineering talent in K-16 education both in China and all over the world, are gaining increased recognition. Some recently published studies have made information about Chinese science education available to the international community, including student achievement such as PISA in 2009, the history and recent reform of science education in China (Liu et al. 2012), and the career hierarchy of K-12 mathematics teachers (NRC 2010). However, less is known about science teacher education and professional development for K-12 science teachers in mainland China. This chapter aims to provide an overview of various professional development models for Chinese science teachers, including typical training programs for preservice teachers in normal universities and four representative models of professional development programs for in-service teachers (i.e., online teacher education programs, model lesson study, workshops for distinguished teachers, and collective lesson preparation).

### *17.1.1 Background*

Beginning in 2000, a new round of education reform began with the notion that education must be oriented toward modernization, the world, and the future. Within

C. Liu (✉) • E. Liu
The College of Life Sciences, Beijing Normal University, 19 Xin jie kou wai Street, Beijing 100875, China
e-mail: liucheng@bnu.edu.cn

© Springer Science+Business Media Dordrecht 2017

L.L. Liang et al. (eds.), *Chinese Science Education in the 21st Century: Policy, Practice, and Research*, Contemporary Trends and Issues in Science Education 45, DOI 10.1007/978-94-017-9864-8_17

1 year, the new science curriculum standards for Grades 1–9 were released by the MOE (Ministry of Education [MOE] 2001). Two years later, high school science curriculum standards were released (MOE 2003a, b, c). In January 2012, the MOE issued the revised edition of science curriculum standards for Grades 1–9.

Along with the implementation of these science curriculum standards in most schools throughout the country was a shift in emphasis from the transfer of knowledge to the development of students' scientific literacy. In particular, the development of a deeper understanding of significant scientific concepts through inquiry-based teaching is becoming more highly emphasized in Chinese science education (MOE 2011; Liu 2011, 2012).

Only when individual teachers are able to understand these new science curriculum standards and use their own pedagogical content knowledge to teach in a manner consistent with the beliefs and goals of this new approach is it possible for classroom teaching practices to meet these standards. In other words, teachers' professional development is a key to ensuring the success of the curriculum reform efforts.

There are over 1.25 million K-12 science teachers in mainland China, with a broad range of academic backgrounds. Table 17.1 presents the number of teachers and students by science subject and by grade level. According to the MOE's educational statistics (MOE 2015), 476,290 full-time science teachers are employed at senior secondary schools to teach separate science subjects. At junior secondary schools, science is taught as a separate science curriculum nationwide but as an integrated subject in a few provinces. Junior secondary schools employ 597,778 science teachers to teach 43,846,297 students in Grades 7–9, and 184,967 science teachers are employed at primary schools to teach integrated science in Grades 1–6. The student-teacher ratio varies in different areas of the country due to differences in the economic, social, and educational conditions between different

**Table 17.1** The number of teachers and students by science subject and by grade level

| | Primary school | | Junior secondary school | | Senior secondary schools | |
|---|---|---|---|---|---|---|
| | Full-time teachers | In-school students | Full-time teachers | In-school students | Full-time teachers | In-school students |
| Physics | Not applicable[a] | | 236,822 | 43,846,297 | 145,594 | 24,004,723 |
| Chemistry | | | 151,323 | | 140,126 | |
| Biology | | | 143,084 | | 101,897 | |
| Geology | | | 135,442 | | 88,673 | |
| Integrated science | 184,967 | 94,510,651 | 31,107 | | Not applicable[a] | |
| Total | 184,967 | 94,510,651 | 597,778 | 43,846,297 | 476,290 | 24,004,723 |

MOE (2015)

Data is cited from year 2014 Statistics Report published online by MOE in 2015. The data show the number of teachers and students in year 2014

[a]Data is not applicable because physics, chemistry, biology, and geology subjects are not taught separately in primary schools, and science is not taught in the integrated way in senior secondary schools

schools, school districts, cities, and provinces. Some teachers teach fewer than 30 students per class, while some teachers in other provinces teach more than 60 students per class.

In addition to the student-teacher ratio, teachers work in different provinces and settings (urban, suburban, or rural) and are diverse not only in terms of their dialects, cultures, and economic conditions but also in terms of their teaching beliefs, instructional goals, skills, and teaching experience. In mainland China, there is a clear career hierarchy with a series of titles representing in-service teachers' professional development progression from "junior rank" to "intermediate rank" and on to "senior rank" and finally "master teacher" (i.e., 特级教师 in Chinese). Teachers must meet specific criteria to be promoted to a higher rank; for example, to reach higher ranks, teachers must conduct research, publish their findings in scholarly journals (in Chinese), and participate in teaching skill contests.

In the context of the new round of education reform and the large number and great diversity of teachers, initiating a standards-based professional development community for science teachers is crucial to fulfill the intentions and goals of the new science curriculum standards.

### *17.1.2 Rationales for Teachers' Professional Development Models*

Professional development models designed for Chinese science teachers are built on the theory of pedagogical content knowledge (PCK) established by Lee Shulman (Shulman 1986, 1987). It is clear that teacher educators and researchers have identified pedagogical content knowledge as a critical component of the knowledge needed to teach (Gess-Newsome 1999). Based on Shulman's work, many different definitions and frameworks of PCK have been proposed. However, among all the various conceptualizations of PCK, there is always essential elements:

> At the heart of PCK lies what teachers know about how their students learn specific subject matter or topics and the difficulties or misconceptions students may have regarding this topic related to the variety of representations (e.g., models, metaphors) and activities (e.g., explications, experiments) teachers know to teach this specific topic. These components are mutually related: The better teachers understand their students' learning difficulties with respect to a certain topic and the more representations and activities they have at their disposal, the more effectively they can teach about this topic. (Van Driel et al. 2014, pp. 849)

PCK could be defined as "the knowledge that a teacher uses to provide teaching situations that help learners make sense of particular science content" (Loughran et al. 2001, p. 289). The development of a preservice teacher education program in mainland China is an application of the theory of PCK, which is embodied in the integration of studying science knowledge with the application of knowledge about learning, pedagogy, and students to actual teaching practice. The teaching practicum is emphasized in the development of teacher education program to help teacher integrate the content knowledge and pedagogical knowledge into topic-specific PCK. In sum, the notion of PCK is embedded in in-service teachers' professional development models in either explicit (online teacher education programs) or implicit ways (other in-service teacher education programs).

The second rationale behind the development of science teacher education programs is the need for engaging both prospective and practicing teachers in professional learning communities, in which teachers could work collaboratively among peers. A professional learning community has been defined as a school environment where teachers work collaboratively in purposefully designed groups to improve student achievement within a structure of support provided by the school administrator (Ontario Principals' Council 2008). Collaboration is important in successfully supporting the use of new practices among teachers (Luft and Hewson 2014). Facing the great diversity of science teachers in mainland China, professional learning communities are established not only at the school level (collective lesson preparation) but also at the school district (model lesson study and workshops for distinguished teachers) as well as provincial or national levels (online teacher education programs). These professional learning communities are based on the belief that PCK could be best understood and used through critical reflection among peers with similar professional experiences.

Finally, teaching is itself complex, requiring constant learning and reflection. New knowledge, skills, and strategies for teaching come from a variety of sources, including research, new materials and tools, descriptions of best practices, colleagues, supervisors, self-reflection on teaching, and reflection on the learning of students in the classroom. It is very important that teachers continually consider and contribute to the advances in knowledge regarding teaching and learning (NRC 1996). Loughran (2014) pointed out that learning about science teaching through reflection on experience is a necessary and effective way for teacher education. He summarized many professional development programs to illustrate how important both student teachers and experienced teachers need real opportunities to learn from their experiences, not to just have experiences. Therefore, providing opportunities for teachers to engage in both self-reflection and collegial reflection about the clinical experience or practicum of teaching is another priority for teacher education programs in mainland China.

## 17.2 K-12 Preservice Science Teacher Education

According to the Teacher's Law of the People's Republic of China issued in 1993 (Standing Committee of National People's Congress 1993), a teaching license is required for employment as a teacher in the K-12 education system. Both education experience with specialization in a certain science discipline (studying science content knowledge) and a certification of pedagogical training (studying pedagogical knowledge) are necessary to apply for a science teaching license. In alignment with the requirement of getting a teaching license, training programs for preservice science teachers are designed to help teacher candidates obtain a deeper understanding about both science content and pedagogical knowledge and apply this understanding to their lesson plans and teaching practice.

### *17.2.1 Institutions Responsible for K-12 Preservice Science Teacher Preparation*

The education system in mainland China begins with kindergarten. Chinese students attend school from kindergarten through 12th grade, in primary schools (grades 1–6) and secondary schools (grades 7–12). Tertiary education refers to grade 13 and upward and is also known as higher education or college or university education. Children are enrolled in the education system when they are 5 or 6 years old. Teacher education programs described in this chapter involve only the professional development of teachers who currently or will soon hold teaching positions in kindergarten, primary, and secondary schools. Teachers holding positions in tertiary education are not considered.

Institutions approved to provide education for K-12 teachers are incorporated into the secondary and the tertiary education level. At the secondary education level, only certain types of vocational schools, called early childhood normal schools and secondary normal schools, are specialized in preservice science teacher education programs. All of the programs held at early childhood normal schools are designed specifically for preparing kindergarten teachers. However, graduates from secondary normal schools may be allowed to teach at both elementary school and kindergarten. Candidates enrolled in these institutions always spend approximately 3 years developing their PCK specific to teaching in kindergarten and primary school. All graduates have over 12 years of education experience before becoming a science teacher in kindergarten or elementary school. Graduates from other secondary schools without further education experience are not allowed to teach. At the tertiary education level, only normal university and certain types of junior colleges (called specialized higher normal schools or normal colleges) are eligible to offer preservice science teacher education programs. Both graduation certificates and academic degrees could be awarded by normal universities, whereas junior colleges offer graduation certificates only. Students enrolled in preservice science teacher education programs in normal universities may obtain teaching certifications as soon as they are qualified to graduate from a normal university. Graduates from other colleges or universities with 4 years' schooling or more are also allowed to apply for a teaching license if they submit a certification of credit hours in education and psychology courses and pass the national teachers' qualification examinations. Today, the blending of the aforementioned vocational schools into the secondary education level occurs primarily in rural areas. Almost all preservice teacher education programs in urban areas, such as in Beijing, are offered in colleges or universities.

The grades that preservice teachers are allowed to teach depend on the levels and types of the vocational schools, colleges, or universities from which these teachers have graduated. According to the Teachers Law of the People's Republic of China issued in 1993:

> (l) To obtain qualifications for a teacher in a kindergarten, one shall be a graduate of an infant normal school or upwards. (2) To obtain qualifications for a teacher in a primary school, one shall be a graduate of a secondary normal school or upwards. (3) To obtain qualifications for a teacher in a junior middle school, or a teacher for general knowledge courses and specialized courses in a primary vocational school, one shall be a graduate of a specialized higher normal school, or other colleges or universities with two or three years' schooling or upwards. (4) To obtain qualifications for a teacher in a senior middle school, or a teacher for general knowledge courses and specialized courses in a secondary vocational school, technical school or a vocational high school, one shall be a graduate of a normal college or other colleges or universities with four years' schooling or upwards. (Standing Committee of National People's Congress 1993)

### *17.2.2 Admission into Preservice Science Teacher Preparation Institutions*

Admission into a science teacher preparation institution is determined based on both candidates' university applications and their scores on entrance exams (paper and pencil tests, i.e., 高考 in Chinese). As they approach the end of their K-12 school education, candidates need to take entrance exams for further education and apply to institutions in which they are interested. And the institutions admit students based on their scores and grade history.

At many of the institutions at the tertiary education level cited above, some special financial support is available to recruit qualified preservice science teachers from rural areas. The dominant source of support is called the "Government-Sponsored Normal Students Program," which was instituted in 2007. Under this program, students from rural areas are enrolled tuition free into preservice teacher education programs in normal universities. Once they graduate from a normal university, they must return to their home rural area to teach for 10 years in a K-12 school. The government will guarantee their teaching position in the rural area.

Every student recruited into preservice science teacher preparation programs in normal universities has shown good performance in the entrance exam, as have students from rural areas enrolled in the "Government-Sponsored Normal Students Program." In other words, the admission into preservice science teacher education programs is based on the applicants' academic performances, regardless of their financial situations.

### 17.2.3 *Typical Preservice Science Teacher Preparation Programs at Normal Institutions*

The teacher preparation programs at all of these institutions are typically 2–4 years in length and focus on both the theory and practice of science content and pedagogical knowledge. The graduates will obtain a teaching license without extra exams so long as they accumulate enough credits in both the science subject areas and pedagogy domains and are qualified to graduate. Graduates from nonteacher preparation colleges or universities—that is, not the normal institutions mentioned above—may also apply for teaching licenses if they pass additional qualifying exams to obtain pedagogy certification.

Table 17.2 below presents a typical preservice biology teacher education program designed by one of the top six normal universities in China. The teacher candidates must earn 175 credits (1 credit represents 1 class hour per week) to graduate and obtain the teaching license during their 4-year tertiary education experience.

All preservice teachers are selected from different provinces by national entrance exams for higher education. Teacher candidates are required to take three types of courses, including "general courses," "professional courses," and "teacher education courses," to complete their training program.

A total of 44 credits are allotted for general courses, in which participants learn the arts and humanities (e.g., literature, history, and philosophy) and fulfill physical education requirements. Teacher candidates must complete all of these general courses by their third year.

Taking the biology program as an example, to gain a deep understanding about biology content and be proficient in biological experimental skills, students must take professional courses, starting from some courses in related subject areas during

**Table 17.2** A 4-year preservice biology teacher education program in normal university A

| Category of course | | | Credits | |
|---|---|---|---|---|
| General courses, such as arts and history | | | 44 | |
| Professional courses | Courses in a related subject area, such as chemistry and physics | | 33.5 | 92 |
| | Biology courses | Basic courses in biology, such as microbiology and genetics | 33.5 | |
| | | Specialized courses in biology, such as animal behavior and ornithology | 25 | |
| Teacher education courses | Compulsory courses, such as educational psychology | | 16 | 39 |
| | Education research courses, such as practice in biology education research | | 4 | |
| | Teaching practice | | 11 | |
| | Professional integrity | | 2 | |
| | Thesis | | 6 | |
| Total | | | 175 | |

the first 2 years, such as undergraduate mathematics, organic chemistry, physical chemistry, and basic physics. In the second and third years, students focus primarily on basic biology courses, such as general zoology, general botany, biochemistry, molecular biology, microbiology, genetics, and cell biology. In addition to taking basic biology courses, participants are required to choose some specialized courses (e.g., animal behavior, genetic engineering, or immunology) to specialize in certain biological subfields.

During the third and fourth years, teacher candidates focus on teacher education courses, including compulsory courses such as educational psychology, pedagogy of biology, comprehensive experiments for biology education, and teaching skills training. In these teacher education courses, general pedagogical knowledge, curriculum knowledge, and knowledge about learners are taught. For example, in the pedagogy of biology course, preservice biology teachers must be aware of students' alternative, prescientific ideas about K-12 biology topics and learn how to apply conceptual change models and other constructivist strategies in science teaching. In addition, knowledge about the K-12 biology and science curriculum reform in both mainland China and all over the world will be taught in order to help preservice biology teachers better understand the context of the biology curriculum. In the meantime, preservice teachers must learn teaching strategies to initiate and support students' scientific inquiry, knowledge about performance and summative assessment, and so on, in the context of the K-12 biology domain. Also, they are required to earn four credits in education research courses, such as practice in biology education research and reform trends of middle school biology education, to familiarize themselves with reform trends and standard educational research methods.

Teacher candidates must then participate in a teaching practicum for at least 6 weeks in a school where they have the opportunity to apply their understanding of biology and education in an actual classroom teaching setting. Preservice teachers involved in the Government-Sponsored Normal Students Program will practice teaching for almost half a year in K-12 schools, considering that these candidates will certainly become teachers as soon as they have graduated. During the teaching practicum, every trainee will be assigned to a K-12 school as a student teacher to teach in a real classroom setting under the supervision of a certified teacher. Each student teacher must have two certified teacher supervisors. One of these supervisors is an experienced science teacher, who allows the inexperienced student teacher to observe teaching in the classroom and then helps the student teacher revise their teaching plan and provides onsite support. This experienced science teacher usually also invites the student teacher to join the in-service collective lesson preparation community at the school level (see Sect. 17.3.4 in this chapter). Another certified teacher is always a homeroom teacher who has the responsibility for taking care of students' in-school lives. The student teacher is also required to act as the assistant to the homeroom teacher throughout the day, observing how to manage students' affairs and assisting in addressing students' problems.

The last step for teacher candidates to apply for a diploma is to design and implement a study and to write a thesis. Usually, these studies focus on biology research topics, such as cellular and molecular domains, ecology, and zoology. Through the thesis study, preservice teachers can not only learn more about certain biological topics but also understand more about real scientific inquiry in the natural science domain. Along with ongoing science education reform that started in 2000, some teacher candidates focus their thesis on the K-12 biology education domain. They do literature and descriptive research about what students know about certain biology topics, what their prescientific concepts are, what good inquiry teaching and learning is from the teachers' perspectives, what characteristics different textbooks have to support conceptual and inquiry teaching and learning, and so on. Through the process of designing and implementing these kinds of thesis studies, preservice teachers can not only develop their understanding and abilities about science education research but also learn more about their students, colleagues, and instruction materials.

Similar to the above preservice biology teacher education program, Table 17.3 below presents a typical preservice physics teacher education program designed by the same normal university. Participants must earn 160 credits to graduate and obtain a teaching license during their 4-year tertiary education experience.

This training plan for physics preservice teachers has a credit distribution that is very similar to that of the biology preservice teacher education program. The main differences are the courses related to the specific science disciplines. In addition, the programs designed for chemistry and geology preservice teachers at the same university have similar course structures to the one described above. Teacher education programs at different universities vary in course offerings and credit requirements. Table 17.4 below shows a sample biology preservice teacher education plan from another of the top six normal universities.

In this case, teacher candidates are required to earn fewer credits, and all courses and credits are categorized differently from those in university A. However, the

**Table 17.3** A 4-year preservice physics teacher education program in normal university A

<table>
<tr><th colspan="3">Category of course</th><th colspan="2">Credits</th></tr>
<tr><td colspan="3">General courses, such as arts and foreign language</td><td colspan="2">44</td></tr>
<tr><td rowspan="3">Professional courses</td><td colspan="2">Courses in related subject area, especially mathematics</td><td>18</td><td rowspan="3">80</td></tr>
<tr><td rowspan="2">Physics courses</td><td>Basic courses in physics, such as mechanics, thermodynamics, and electromagnetics</td><td>43</td></tr>
<tr><td>Specialized courses in physics, such as general relativity and general astronomy</td><td>19</td></tr>
<tr><td rowspan="5">Teacher education courses</td><td colspan="2">Compulsory courses, such as educational psychology</td><td>12</td><td rowspan="5">36</td></tr>
<tr><td colspan="2">Education research courses, such as research on teaching physics experimentation in grades 7–12</td><td>2</td></tr>
<tr><td colspan="2">Teaching practice</td><td>11</td></tr>
<tr><td colspan="2">Professional integrity and scientific research training</td><td>3</td></tr>
<tr><td colspan="2">Thesis</td><td>8</td></tr>
<tr><td colspan="3">Total</td><td colspan="2">160</td></tr>
</table>

**Table 17.4** A 4-year preservice biology teacher education program in normal university B

| Category of course | | Credits | |
|---|---|---|---|
| General courses, such as history and foreign language | | 30 | |
| Basic courses | Compulsory courses, such as inorganic chemistry, organic chemistry, zoology, botany, psychology, and lesson planning | 35 | 47 |
| | Elective courses, such as philosophy of education and curriculum design and evaluation | 12 | |
| Specialized courses | Compulsory courses, such as molecular biology, cell biology, and ecology | 22 | 30 |
| | Elective courses, such as developmental biology, immunology, and parasitology | 8 | |
| Innovation | Research project or publication | 3 | 3 |
| Practice | Teaching skills training | 2 | 20 |
| | Teaching practice and field experience | 10 | |
| | Thesis | 8 | |
| Total | | 130 | |

pattern of focus on both a specific discipline and related science content knowledge and pedagogical knowledge is similar. For example, during the courses of zoology, botany, molecular biology, and so on, Preservice teacher needs to get deeper understanding about discipline and content knowledge to differentiate between the misconception and scientific conception. In the meantime, during the courses of psychology, lesson planning, teaching skill training, and so on, they need to know better about students' learning difficulties with respect to a certain biology topic and the more activities that might help students change their prior understanding. In addition, the teaching practicum is included as an indispensable component based on the same concern that preservice science teacher education should not only help participants obtain a deeper understanding of the content and pedagogical knowledge but also apply their knowledge to actual classroom teaching.

Although the structure of training programs in different institutions appears slightly different, they share two common characteristics. First, the training programs for preservice science teachers are designed in alignment with the PCK perspective too. These programs are conducted primarily by science departments comprising both scientists and education specialists. Candidates are trained not only in pedagogical knowledge and teaching practices by educators but also in science and scientific research by scientists from respective science departments. Such programs thereby make preservice teachers well-rounded in terms of their science backgrounds. Second, credits for general courses, such as arts and history, are required in all of the preservice science teacher's preparation programs. This common feature indicates that training programs are designed to develop not only teachers' PCK with regard to a certain science subject area but also their spirit and literacy in humanities. The full development of teachers' characters is of greater consideration than the sole development of technical teaching skills.

## 17.3 Professional Development for In-Service Science Teachers

After graduating from teacher's preparation programs, preservice teachers obtain a job and enter the professional development system, becoming in-service teachers. Teachers are granted a title based on their academic degree and teaching experience in the field. For example, new secondary school science teachers who have master's degrees can obtain a junior rank at the end of their first full year of teaching, whereas at least 3 years of teaching experience is required for new teachers with bachelor's degrees to obtain the same rank. In the meantime, the supervision of a new teacher's full year of teaching is part of the responsibilities of teachers with intermediate or higher ranks. Junior-ranking teachers must accumulate more teaching experience and a certain number of credits in in-service professional development every year, participate in teaching skill contests, and investigate some teaching problems to be promoted to the intermediate ranks. To earn a senior rank, a teacher must have a deep understanding of science content and pedagogical knowledge, be able to implement a sound science teaching research program, and make an important contribution in training lower-ranking teachers. The requirements to earn a master teacher rank are the most rigorous. This honorary title is awarded only to teachers who have significant ideas about both the science discipline and educational theory and practices in K-12, are able to initiate and conduct an educational research program, publish enough papers in science teaching journals (in Chinese), are advocated for by most peer teachers, and make outstanding contributions in training lower-ranking teachers.

The evaluation criteria for promoting teachers from one rank to the next may differ slightly between schools, schools districts, cities, and provinces. The description above is the general situation across mainland China. The salary and available resources for teachers are associated with their title (except for the master teacher). For example, an intermediate-ranking teacher would be paid higher than a junior-ranking teacher if they get exactly the same job in the same school. However, the pay scale varies depending on the financial and economic development status of the school district or local community. The title of master teacher is only honorary and has no differences in salary and recourses. This type of title promotion may represent an incentive for teachers to participate in in-service teacher professional development as shown below.

In-service teachers may earn credits either as full-time (or part-time) teachers or while on a leave of absence from work with approval by the MOE. A national in-service teacher education program has recently begun to enroll science teachers from all over the country. Participating teachers are allowed to take a leave of absence from their work to participate in more intensive face-to-face training workshops. Their work is taken over by preservice science teachers who have already earned all of the necessary credits in science subject content and education theory and who are ready to become student teachers. This policy offers in-service teachers more time for their professional development while affording preservice teachers greater opportunities to integrate theory with classroom practice. The face-to-face professional development programs, combined with online teacher education, are funded by the MOE with approximately 500 million Chinese yuan financial support, including payments for participating teachers and preservice teachers.

However, many teacher education programs are also designed for science teachers with full-time or part-time positions who are unable to be absent from their work. Four types of these programs are described in the following sections: online teacher education programs, model lesson study, workshops for distinguished teachers, and collective lesson preparation.

### 17.3.1 Online Teacher Education Programs

With the new round of education reforms beginning in 2000, the new national science curriculum standard turned its focus from emphasizing knowledge to emphasizing the development of students' scientific literacy through inquiry-based teaching. This standard requires that in-service teachers' training be developed in a manner consistent with this shift to ensure that the curriculum reform efforts will be effectively transferred into real classroom teaching. However, engaging in face-to-face teacher education poses a practical problem due to the huge number of teachers with diverse backgrounds and a lack of teacher educators. Online teacher education programs have been designed and conducted to solve this problem.

From 2007 to 2011, a nationwide standards-based online professional development program, funded by the MOE, was initiated for in-service science teachers throughout the country. The program was developed by the same team who designed the national curriculum standards. This program focused on helping science teachers translate the aims and goals of the national curriculum standards (e.g., "developing student scientific literacy," "science for all children," and "teaching science through inquiry"), into their daily classroom practice.

Under this model, teachers may access any online community they like, but they are preassigned to an online community of teachers based in their own province. In this program, participants come from urban, suburban, or rural areas with great diversity in not only their demographic background, comprising their dialects, culture, and economics, but also their teaching beliefs, skills, and experience. This high level of diversity made the program quite challenging but also highly rewarding, as teachers were able to learn from each other.

A panel of teacher education experts was assembled, including the designers of national curriculum standards, master teachers, teacher educators, and science education researchers from universities. They all had access to an online community to provide feedback and suggestions to teachers. In the meantime, every participating teacher had free access to online videos and was able to submit his assignments, check peer and trainer reviews about his/her assignments, make

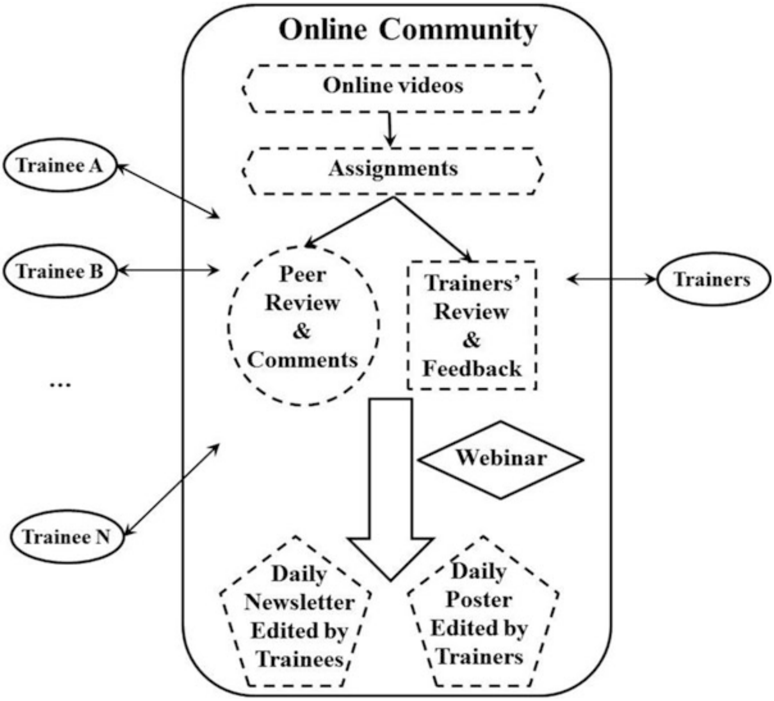


**Fig. 17.1** Work pattern for online teacher education programs

comments on others' assignments, participate in webinars, and follow daily newsletters and daily posts from his online community (See Fig. 17.1).

The typical duration of the program was ten consecutive days during summer vacation. Every morning, participants logged onto their own unique online account containing their personal academic record and watched online videos concerning the panel's comments and suggestions regarding a special topic related to a real classroom teaching situation. At the end of the videos, a few reflective questions by the trainee panel were presented. Participating teachers were required to use their own real teaching experiences as examples to illustrate their answers to these questions. In the afternoon, teachers began to write down their answers and upload them to the online community through their accounts. In the meantime, teacher educators reviewed teachers' answers and gave brief feedback. Teachers could also read others' answers and make comments to each other. In the evening, a daily post summarizing the key points produced from the entire day of online training was published by teacher professional development leaders to all of the participants in order to review the most important concepts. In addition, participating teachers made similar summaries for themselves by editing and publishing a daily newsletter. In addition, participants were required to join in the online webinar every 3 or 4 days, communicating with the science educator about any difficulties they faced when trying to apply the new standards to real classroom teaching. Participating

**Table 17.5** An outline of the national online professional development program for grades 10–12 biology teachers

| Topics | Questions addressed and discussed in the video |
|---|---|
| Topic 1: the rationale for changing the biology curriculum and implementing the principle of the curriculum into real classroom teaching | What is the difference between the new biology curriculum standards and the old ones? |
| | How should teachers understand the principles of the new curriculum? |
| | What knowledge and skills are necessary for teachers to translate the principles of the new curriculum into real classroom teaching? |
| Topic 2: the content changes in biology curriculum and its challenges | What challenges will students encounter while implementing the new curriculum? |
| | How can teachers manage the new content knowledge? |
| | How can teachers teach effectively in response to the changes in curriculum? |
| Topic 3: achieving the goal—"Teaching the Big Ideas of Biology" | What is your opinion of the "big ideas" required in the national biology curriculum standards? |
| | How is it possible to select big ideas from given content? |
| | How can one teach big ideas effectively in a biology classroom? |
| Topic 4: achieving the goal—"Cultivating Students' Active Learning" | What characteristics does the inquiry-based teaching approach have? |
| | What content is adequate for inquiry-based teaching? |
| | How does one teach biology through inquiry in a classroom with a large student-teacher ratio? |
| Topic 5: achieving the goal—"Teaching Effectively with a Lecture and Demonstration Approach" | What is your opinion about the effectiveness of the use of a lecture and demonstration approach in biology classroom? |
| | What content is better suited for lecture than for inquiry? |
| | How does one teach biology in an effective way by using demonstration? |
| Topic 6: teaching compulsory module 1—"Molecules and Cells" | What issues should be noticed while teaching this module? |
| Topic 7: teaching compulsory module 2—"Genetics and Evolution" | Which parts are the most important or difficult to teach in this module? |
| Topic 8: teaching compulsory module 3—"Stability and Environment" | How does one teach the big ideas in this module? |
| Topic 9: teaching elective module 1—"Practice of Biotechnology" | How does one propose a feasible and affordable list of new equipment for the biology labs in your school? |

(continued)

**Table 17.5** (continued)

| Topics | Questions addressed and discussed in the video |
|---|---|
| | How does one choose the biotechnological activity available in the curriculum given the current condition of your school? |
| | How can the success rate of biotechnological practice be improved? |
| Topic 10: assessments in biology teaching | What principles and assessment methods are consistent with the requirements of the new curriculum standards? |
| | What are the assessment strategies for class-room teaching and how should they be used? |
| | What are the assessment strategies for lab-based teaching and how should they be used? |
| | How does assessment encourage students' active learning? |

teachers could post their questions through an online forum. Science educators checked the messages and questions posted by participants and chose the most typical questions to make comments on and suggestions for all participants through the forum system.

For example, Table 17.5 is an outline of this program for training biology in-service teachers for grades 10–12. Typically, ten topics were given, including the understanding of the beliefs and goals of new biology curriculum standards, analysis of PCK (containing biological subject knowledge, general pedagogical knowledge, curricular knowledge, knowledge about learning, and knowledge about educational contexts), and the means of incorporating these new standards into real classroom teaching practices.

From 2007 to 2011, science teachers from all provinces in mainland China participated in such online program. This professional development model has been used for both elementary and secondary teachers not only at the national or provincial level but also at the county or town level. More and more websites are being built to integrate multiple online resources for in-service teachers' learning and practicums. This program made its contribution to ensure the success of the national curriculum reform amid the large number of teachers with great diversity and a lack of teacher educators.

### *17.3.2 Model Lesson Study*

Model lesson study is a type of professional development workshop for in-service teachers at the school district level. This program provides on-site peer review for teachers, who demonstrate their classroom teaching in front of other teachers, and it provides opportunities for teacher observers to reflect on what they have observed and make connections to their own classroom practices. In every school district, there is a special occupational position called the "subject coordinator" (教研员in Chinese), who is responsible for initiating in-service teacher education in a certain subject area. Experienced senior-ranking teachers are eligible for this type of position.

The subject coordinator first identifies a teacher (either an experienced teacher or a new faculty member at a school) who has creative ideas for teaching certain science content in nontraditional ways. The coordinator then calls all of the teachers in this subject from the same school district to observe this teacher's model lesson together. After the classroom observation, the subject coordinator initiates a workshop featuring peer review and discussion about this model lesson. The teacher who designs this lesson is also invited to participate in the workshop to explicitly illustrate her/his creative ideas. The subject coordinator and other teachers then provide their opinions and further suggestions.

During peer review and discussion, collegial reflections from the subject coordinator and other teachers may help the model lesson designer to self-reflect in order to improve his/her teaching practice. Meanwhile, observing teachers also benefit from self-reflection regarding how to incorporate the best ideas from this model lesson into their own class. These mutual benefits between the model lesson designer and other teachers derive from the similar teaching environments they share within the same school district.

In addition, exemplary model lessons are invited for exhibition at annual provincial or national conferences on this subject area. It is in this manner that creative ideas about science teaching can be spread over different cities or provinces and impact actual classroom teaching throughout a province or the entire country.

### *17.3.3 Workshops for Distinguished Teachers*

This professional development program was designed specifically for teacher leaders who are responsible for leading and developing other teachers. This program, which is usually initiated and funded by the District Board of Education and aims to help experienced teachers to be more effective leaders of the professional learning community at either the school level or the school district level. Only teachers who have made important contributions to the school district may be enrolled in this program.

Participants have access to several integrated resources, such as one-on-one interactions with mentors who are distinguished master teachers in the same subject area or play a key role within the science education system. They also get ample opportunities to observe their mentors' or other expert teachers' real classroom teaching, free access to book review salons and academic forums, an open platform to design and implement science education research, and different ways to reflect

**Table 17.6** Sample schedule of Haidian Cadreman Teachers Academy

| Session | Assignments |
|---|---|
| Phase I: developing self-plan and attending multifaceted activities (6 months) | Teachers share their own ideas and situations focusing on professional development orientation and goals with their colleagues and mentors |
| | Then, a series of workshop and routine activities will open for each participant, such as book review salons, academic forums, and classroom teaching observations and review (e.g., "model lesson study") |
| | Finally, teachers must design specific professional development plans for themselves with clear statements about what they really need and how they want to develop |
| Phrase II: fulfill the self-plan through designing and implementing science education research supported by collaboration (24 months) | Teachers continue to attend book review salons, academic forums, and classroom teaching observations and review |
| | In the meantime, teachers have discussions with other program participants on the topics they are interested in. Participants find a way to perform a collaborative study as a team |
| Phrase III: summary and reflection (6 months) | Teachers publish and communicate their achievements and findings with other members in this academy. They must also reflect on how to initiate professional development in their own communities, either at the school level or at the school district level |

on their own decision making in teaching and studying. Participants must dedicate themselves to this program for at least 3 years. Table 17.6 above shows an example model called the Haidian Cadreman Teachers Academy.

This model differs substantially from other professional development models mentioned in this chapter because it aims to cultivate teacher leaders of the professional learning community. This program is designed for experienced teachers who have the ability and ambition to make more significant contributions for their school district or school—that is, it is not intended for new teachers or ordinary teachers.

### *17.3.4 Collective Lesson Preparation*

This is a professional development model for in-service teachers at the school level. Within a school, teachers who teach the same science subject for the same grade always belong to the same collective lesson preparation community. Student teachers (aforementioned in Sect. 17.2.3) are always invited to join in the community during their teaching practicum in a K-12 school.

In this community, teachers share their opinions and comments about the unit plan. First, they hold discussions on the objectives, curricular schedules, the most important ideas that should be taught, the most challenging concepts that students will encounter, teaching procedures, students' preconcepts, learning activities, series of questioning, and means of evaluation, among others. A senior-ranking teacher or a master teacher always hosts this discussion and leads the community to achieve some common goals.

Second, teachers within the same community of collective lesson preparation work together to turn their idea into a real teaching plan. The lead teacher splits the entire unit into specific lessons and assigns them to individuals. For example, teacher A takes the responsibility for designing all materials for lesson 1, including the lesson plan, PowerPoint documents, resources (i.e., pictures, animations, and website links), and assessment tools, while teacher B takes lesson 2, and teacher C takes lesson 3.

Usually a week later, teachers share all of the lesson materials with one another. The designers of each lesson must explain the rationale and principles behind the students' learning activities they created. In the meantime, other teachers review the designs, make comments, and discuss with each other about how to improve them. Each lesson designer later revises his original design based on the peer reviews and shares the new version of all of his teaching materials with everyone else.

The teachers then receive all of teaching materials for these units from the other teachers and make their own revisions to meet the requirements of the different

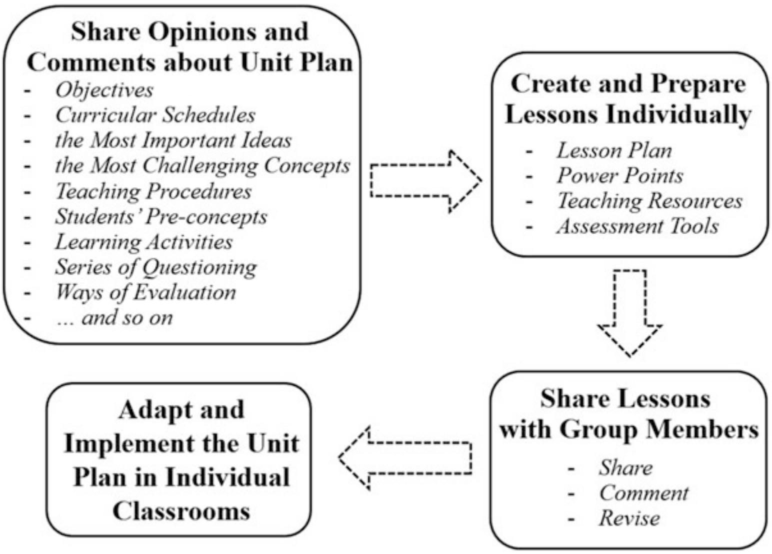


**Fig. 17.2** Collective lesson preparation community

students they teach. Finally, teachers from the same collective lesson preparation community will incorporate the shared teaching unit plan into their diverse classrooms based on their own decisions and revisions (See Fig. 17.2).

Although they teach different students in different classes, teachers within a collective lesson preparation community share a common teaching philosophy and goals, a synchronous or parallel teaching schedule, and almost identical teaching policies and equipment. This similarity helps them gain rapid professional development, especially for the new faculty members, who have a relative lack of teaching ideas, instructional materials, and classroom experience.

## 17.4 Summary

In summary, the system for the professional development of science teachers in mainland China is distributed from the national or provincial level to the school district level and finally to the school level, designed respectively or integrated for all teachers, including inexperienced preservice teachers, new teachers, experienced (intermediate or senior-ranking) teachers, and teacher leaders (See Fig. 17.3). Preservice science teachers may receive training at the national or provincial level by focusing on the theory and practice of science and science education through the approved educational institutions. After they graduate, these teachers may develop their PCK through online teacher education programs (at the national or provincial level), model lesson study (at the school district level), and

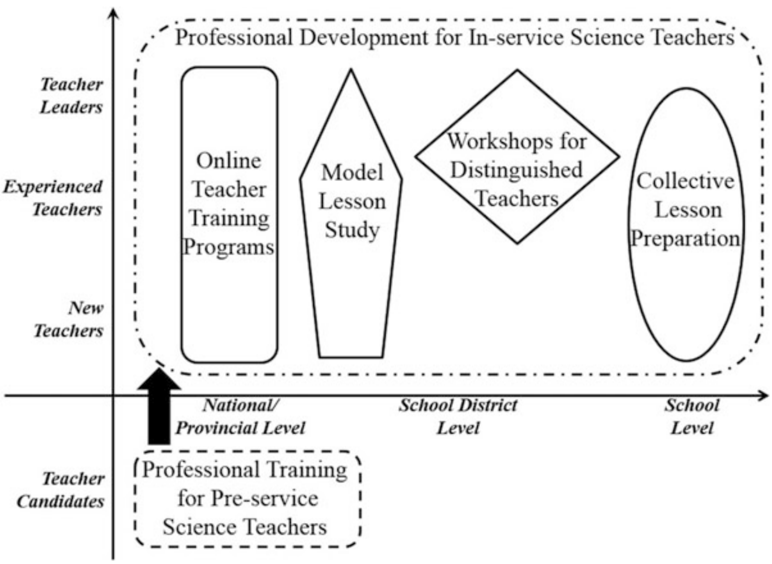


**Fig. 17.3** The science teacher professional development system in mainland China

collective lesson preparation communities (at the school level). New teachers will gain rapid professional development through online teacher education programs, model lesson study, and collective lesson preparation communities. Experienced teachers play demonstrational roles in model lesson studies and collective lesson preparation communities. Some experienced teachers can also get further development through workshops for distinguished teachers, enabling them to be better leaders of their school districts or schools.

The current science teacher professional development system has trained millions of science teachers to meet the demands of a huge of population. It has been shown that by establishing professional learning communities that emphasize curriculum standards, PCK perspectives, and self- and collegial reflections, the preservice and in-service teacher development models described above appear to be working well in mainland China, especially in the context of involving an extremely large number of teachers and students.

However, as Loughran (2014) said, "A great challenge for teacher education programs is to help student teachers see beyond their own experiences of teaching and find new ways to engage them in conceptualizing practice as something more than how they themselves were taught" (p. 812). Teachers are required to teach in a manner that emphasizes the beliefs and goals, for example, teaching and learning in the way of scientific inquiry, advocated by the educational reform and its new science curriculum standards. However, most of science teachers in mainland China do not have the experience of doing real authentic scientific investigation. Therefore, it is really a big challenge for teacher education programs in mainland China to help teachers change their beliefs and behavior to a manner that they themselves were never taught.

In the meantime, the teacher education programs in mainland China are in dire need of more qualified and expert science teachers and educators who are able to do science education research on translating the new science curriculum ideas into K-12 science classroom teaching practices. Along with the gradual implementation of the science curriculum reform started in 2000 into more and more schools, there have been many experience-based articles published in science teacher journals (in Chinese) to share interesting teaching ideas, experiences, and so on. However, in the new round of science education reform, using only experience-based teaching decisions is not sufficient for K-12 science teachers to take the various challenges they are going to encounter. More research-based or evidence-based teaching decisions are also necessary to design and implement effective teaching for a large student population with different backgrounds and experiences. In sum, more empirical-based studies about science teacher professional development, for both preservice and in-service science teachers, are necessary.

**Acknowledgments** Sincere thanks go to Teacher Lehe Xiao, Prof. Hong Cui, Prof. Yuying Guo, Prof. Min Wang, and Dr. Rui Wei for providing the actual K-12 science teacher professional development models to support this chapter. We also gratefully acknowledge the contributions of Prof. Ling Liang and other reviewers who provided valuable comments and suggestions to help revise the draft manuscript.

## References

Gess-Newsome, J. (1999). Pedagogical content knowledge: An introduction and orientation. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 3–17). Dordrecht: Kluwer Academic.

Liu, E. (2011). Prospection on the next ten years of science curriculum development in China (基础教育理科课程改革未来十年展望). *General Education Curricula, 12*, 17–18 (in Chinese).

Liu, E. (2012). Deliver key concepts through inquiry based approaches in school biology—what's new in the 2011 national biology curriculum standard of junior secondary school (在教学中实现主动探究学习与凸显重要概念传递的对接—《义务教育生物学课程标准》修订思路和要点). *Bulletin of Biology, 47*(3), 33–36 (in Chinese).

Liu, X., Liang, L., & Liu, E. (2012). Science education research in China: Challenges and promises. *International Journal of Science Education, 34*(13), 1961–1970.

Loughran, J. J. (2014). Developing understandings of practice. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education (volume II)* (pp. 811–829). New York: Routledge.

Loughran, J., Milroy, P., Berry, A., Gunstone, R., & Mulhall, P. (2001). Documenting science teachers' pedagogical content knowledge through PaP-eRs. *Research in Science Education, 31* (2), 289–307.

Luft, J. A., & Hewson, P. W. (2014). Research on teacher professional development programs in science. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education (volume II)* (pp. 889–909). New York: Routledge.

Ministry of Education. (2001). *National science curriculum standards of the compulsory education (grades. 7–9) (trial version)* (义务教育科学课程标准(实验)). Beijing: Beijing Normal University Press (in Chinese).

Ministry of Education. (2003a). *National biology curriculum standards for high school (trial version)* (普通高中生物课程标准(实验)). Beijing: People's Education Press (in Chinese).

Ministry of Education. (2003b). *National chemistry curriculum standards for high school (trial version)* (普通高中化学课程标准(实验)). Beijing: People's Education Press (in Chinese).

Ministry of Education. (2003c). *National physics curriculum standards for high school (trial version)* (普通高中物理课程标准(实验)). Beijing: People's Education Press (in Chinese).

Ministry of Education. (2011). *National biology curriculum standards of the compulsory education* (义务教育生物学课程标准). Beijing: Beijing Normal University Press (in Chinese).

Ministry of Education. (2015). *Educational statistics in 2014*. Retrieved from http://www.moe.gov.cn/s78/A03/moe_560/jytjsj_2014/2014_qg/

National Research Council. (1996). *National science education standards*. Washington, DC: The National Academies Press.

National Research Council. (2010). *The teacher development continuum in the united states and china: Summary of a workshop*. Washington, DC: The National Academies Press.

Ontario Principals' Council. (2008). Building professional learning communities. In Ontario Principals' Council (Ed.), *The principal as professional learning community leader* (pp. 5–16). Thousand Oaks: SAGE.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Standing Committee of National People's Congress. (1993, October). *Teachers law of the People's Republic of China* (中华人民共和国教师法). Retrieved from http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/moe_2803/200907/49852.html (in Chinese).

Van Driel, J. H., Berry, A., & Meirink, J. (2014). Research on science teacher knowledge. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education (volume II)* (pp. 848–870). New York: Routledge.