

Chapter 2

Professional Development of Secondary Mathematics Teachers in Mainland China

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Abstract This chapter examines major practices of the professional development (PD) of mathematics teachers and relevant supporting infrastructures in Mainland China. The first section provides an overview of the teacher education system in China including teacher preparation, teacher licensure, ranking system, and continuing education. The second section focuses on the main practices of PD programs and their latest developments, which include apprenticeships, hierarchical teaching research, lesson studies and lesson contests, and master teacher development programs. Finally, the authors synthesize a model depicting the system of PD in Mainland China, and discuss what could be learned from Chinese practices.

Keywords Teacher professional development of mathematics teachers • Mainland China • Professional ranking system • Teaching research system • Apprenticeship • Chinese lesson study • Master teacher development

2.1 Background

The efforts to improve student learning in mathematics led researchers to investigate high-achieving education systems and practices in East Asia, including China (Bednarz et al. 2011; Leung and Li 2010; Mullis et al. 2012; OECD 2010). In particular, studies have focused on how Chinese learn mathematics (Fan et al. 2004) and teach mathematics (Li and Huang 2012). However, less attention has been given to how Chinese prepare and develop mathematics teachers (Huang et al.

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2010; Liang et al. 2013), which is a crucial factor influencing students' mathematics learning and achievement (National Mathematics Advisory Panel [NMAP] 2008; Schmidt et al. 2008; Sullivan and Wood 2008). Although Ma (1999) found that Chinese elementary mathematics teachers have profound mathematics knowledge and skills needed for teaching, recent studies suggest that Chinese mathematics teachers do not have adequate preparation in their pedagogical content knowledge (Li et al. 2008). One possibility is that Chinese practicing teachers develop their mathematics knowledge for teaching during practice (Li and Huang 2008).

Studies have revealed some unique features of the mathematics teacher professional system (PD) in China (Huang et al. 2010; Stewart 2006) such as a well-established ranking and promotion system (Li et al. 2011a), institutionalized teaching research system (Yang and Ricks 2012), and ubiquitous public lesson development (Huang et al. 2011; Liang 2011). This chapter aims to provide a comprehensive and updated picture about practices of PD in Mainland China. First, we provide an overview of the teacher education system in China as a background for understanding practices of PD. Then, we examine major practices of PD of mathematics teachers and their latest developments. Finally, we synthesize a model of the PD system and discuss what other education systems may learn from Chinese practices.

2.2 Overview of Teacher Education System in China

This introduction of teacher education system in China includes degree requirements, teacher preparation programs, accreditation system, and ranking system.

2.2.1 Education Degree Requirements

The Teacher Act (Ministry of Education [MOE] 1994) defines teachers' positions, qualifications, and responsibilities. The *Regulations of Teachers' Qualification* (MOE 1995) further states the teacher professional ranking system, and promotion criteria and procedures. According to *The Teacher Act*, the minimum education required for elementary teachers is completion of a three-year program offered by normal schools; the minimum for middle school teachers is completion of a three-year program offered by normal colleges; the minimum for high school teachers is a four-year bachelor's degree. However, with the development of economics and technology, requirements have increased. Primary school teachers are trained in three-year teacher colleges or four-year universities; secondary (including middle and high) teachers are trained in four-year universities, while some high school teachers are even required to attain a postgraduate degree (Wang 2009). Some developed regions in China aimed to implement "one level of institute (four-year university), two levels of degree (bachelor and master degree for school

teachers at all levels).” Typically, primary school mathematics teachers are trained in a college of education at a three-year college or four-year university; secondary mathematics teachers are trained in mathematics departments at four-year universities. The Ministry of Education (1999a, b, 2000) has encouraged comprehensive universities to create teacher preparation programs. Since then, an increasing number of teacher candidates have graduated from comprehensive universities.

Secondary mathematics education programs emphasize providing the preservice teacher with a profound mathematics knowledge foundation and highly advanced mathematics literacy and reviewing and studying of primary mathematics but provide a limited teaching practicum program (Li et al. 2008; Liang et al. 2013). The practice of emphasizing mathematics content knowledge with less attention to pedagogical knowledge and teaching practicum may reflect the beliefs that “university is the best place for learning advanced mathematics content, the core purpose of teacher preparation is to learn subject knowledge because prospective teachers can develop their pedagogical knowledge from their future teaching practice” (Wang 2009, p. 181).

2.2.2 Accreditation System

To obtain a teaching license after earning a bachelor degree (in any areas), aspiring teachers are required to pass both written and oral exams (MOE 2011, 2013a). The written exams include the following content components: Synthesis quality, educational knowledge and skills, subject knowledge, and instructional abilities [mathematics knowledge (41 %), curriculum knowledge (18 %), mathematics teaching knowledge (8 %), and mathematics teaching skills (33 %)].

Once passing the written exams, a teacher candidate is eligible to participate in an interview that further examines knowledge and skills such as professional ethics, dispositions, manners, communication skills, and teaching skills. The interview is composed of two parts. Part A focuses on one structured interview question and one topic for mini teaching while part B takes the form of question and answer with an expert panel (From 2011 to 2013, average pass rates are 35 % for the written exams and 70.9 % for the oral exam) (Wu and Ge 2015). A teacher candidate who passes the written exams and the oral interview obtains a teaching license that will need to be revalidated and registered every 5 years (MOE 2013b).

2.2.3 Ranking and Promotion System

Similar to university faculty promotion systems, professional promotion systems for primary and secondary teachers have been practiced for decades (MOE 1995). According to the regulations (MOE 1995), there are different professional ranks for secondary and primary teachers. For example, the positions within secondary

teacher include senior-rank teacher, secondary level 1, and secondary level 2. For each, there are specifications with respect to political, moral, and academic standings. Local educational authorities provide detailed and specific requirements for promotion at each level. Apart from the described three levels of position rankings, there are some honorary rankings such as “exceptional teacher.” They are the model and experts in terms of morals, educating students, and teaching expertise (see Li et al. 2011a, b for details). As part of the promotion system, teachers have to participate in at least 240 h of professional development over a five-year period (MOE 1999a). Local education authorities determine requirements for teacher continuing education programs for different rank teachers.

In August 2015, the Ministry of Human Resources and Social Security [MHRSS] and Ministry of Education [MOE] of China (MHRSS and MOE 2015a) jointly rereleased a document, *The Guidance for Deepening the Reform of Secondary and Primary School Teachers’ Promotion System* which unifies the ranks for both secondary and primary teachers into three levels that are aligned with other professional ranking systems. The senior-rank level includes full-senior and senior teachers. The intermediate-rank level is called level 1 teacher, and the primary-rank level consists of level 2 and level 3 teachers. For example, full-senior teachers should meet the following criteria: (1) have high, professional aspirations and firm professional beliefs; have experience working as a teacher for a long time and serve as a guide and steering role in prompting students’ growth, and have been an excellent class supervisor and student counselor, and made a great accomplishment in educating students; (2) have a profound understanding and mastering of curriculum standards and subject knowledge; achieved excellent performance in education and teaching, demonstrated an adept in teaching arts, and developed a unique teaching style; (3) have an ability to organize and guide education and teaching research; achieved creative results in educational ideas, curriculum reform, teaching methods, and applied them in teaching practices, and exerted a demonstration and steering role; (4) make exceptional contributions to mentoring and cultivating teachers at level 1, 2, and 3; maintain a high reputation in subject teaching, and have been well-recognized as an education and teaching expert; and (5) normally hold a bachelor or above degree, and have served as an advanced teacher at least five years. For another example, a level 3 teacher (entry level) should meet the following criteria: (1) basic mastery of the principles and methods of educating students, and should be able to appropriately educate and guide students; (2) have educational, psychological, and pedagogical knowledge, and basic mastery of subject matter knowledge and pedagogical knowledge in the subject being taught, and be able to teach a subject; and (3) hold an associate degree or above, and one year successful teaching probation.

Building on the previous regulations (MOE 1995), the recent guidance (MHRSS and MOE 2015a) stresses teacher morality, practical accomplishment, and practical experience, and de-emphasizes academic articles and academic degrees. It suggests the establishment of an evaluation system based on peer expert panel’s evaluation. The panel should include highly respected education and instruction experts and experienced teachers. The evaluation forms should include explaining and delivering

lessons, interviews, and expert reviews. The local authorities' implementation plans should be approved by MHRSS and MOE by the end of 2015. The transfer to, and first implementation of the new system will take place in 2016. And the new system will be fully implemented after a two-year exploration (MHRSS and MOE 2015b).

2.3 Major Practices of Professional Development System

The well-structured and hierarchal teacher professional development system includes: induction programs, practice-based teaching research programs, upgrading degree program, new curriculum training programs, and master teacher training programs.

2.3.1 *One-to-One Mentoring Practice*

A new teacher is usually assigned an experienced teacher as a mentor for the first couple of years (2–3 years). The idea underlying the *one-to-one mentoring practice* is that novice teachers can learn from experienced teachers regarding routine of teaching, basic skills of lesson design, implementation, evaluation, and understanding of textbooks. At the beginning of each academic year, schools form pairs of mentor-mentees and have a celebration for them. Both mentors and mentees sign formal pacts, which describe the responsibilities of both (Huang et al. 2010). The practice not only familiarizes novice teachers with teaching routines and develops their basic teaching knowledge and skills, but it also exposes experienced teachers to innovative teaching ideas and new instructional technologies (Huang and Li 2008; Wang and Paine 2006).

2.3.2 *Practice-Based Teaching Research Activity*

Teaching research activities refer to various activities of professional development institutionalized by four hierarchical organizations: province/city, district/county, school, and lesson plan group. These organizations (*Jiaoyan Shi*) are responsible for guiding teaching research activities, overseeing teaching administration in schools on behalf of educational bureaus, providing consultation for educational authorities, mentoring the implementation and revision of new curricula, building the bridge between modern educational theories and teaching experiences, and promoting high-quality classroom instruction (Huang et al. 2010; Wang 2009; Yang and Ricks 2012). School-based teaching research groups (TRG) are the basic organizations that organize teaching research activities. We describe teaching research activities in three clusters: routine activity, competitions, and new developments.

2.3.2.1 Routine Teaching Research Activity

There are school-based and across school teaching activities. The school-based teaching activities include two forms: mathematics teaching research groups and grader-based (with other subjects) lesson plan preparation groups. Mathematics teaching research groups are responsible for designing and implementing the teaching and research schedule in each semester or academic year. Grade-based lesson plan groups are responsible for the organization and guidance of lesson plans at that grade. There is a variety of teaching research activities beyond school level (city, district/country levels). For example, in a big southeast city, an academic year includes four big activities in a semester, one activity per month (These activities usually were scheduled on Friday morning). In each activity, the theme and facilitator are preassigned so that each activity can focus on a specific topic. Knowledgeable experts (master teachers, teaching research educators, and faculty from universities) are invited to give lectures or model lessons for teachers. These activities often focus on analyzing textbooks and teaching reference materials, and exploring effective strategies of teaching with an emphasis on college entrance exam preparation (Huang et al. 2010).

2.3.2.2 Various Competitions Focusing on Teaching Skills

Besides routine teaching research activities, educational authorities, and teaching research institutes organize various competitions focusing on teaching skills at both local and national levels. They include lesson competitions, explanation lessons, and explaining problem solving.

Teaching competition classes held for young teachers (under 30 years old) at school, district, city, province, and national levels. Teachers who are under 30 years old are encouraged to participate in teaching competitions. Teachers who participate in the competition select a topic from a predetermined list. Winners at the school level are recommended to participate in the district level competition; winners of district level competitions move up to the city level competition; winners of city level competitions proceed to the province level of competition; finally, the winners of the province level competitions go to compete in the national level competition. However, the competition lessons are collaborative results. For instance, a competition lesson taught at the city level is a collaborative effort of master teachers and teaching researchers within a district. Liang (2011) concluded that these activities provide teachers with opportunities to share their ideas, constantly conduct reflective thinking on teaching, and learn actively from each other. By examining a nationwide lesson competition, Li and Li (2009) found that that lesson competitions could improve teaching to better align with the criteria of an exemplary lesson valued in Chinese culture.

The explaining lesson competition is a variation of lesson competition in which the participant teachers analyze teaching content, identify teaching objectives, select appropriate teaching methods, explain the major processes of teaching, and explain

assessment of student learning during the lesson. Similar to lesson competition, there are multiple levels of explaining lesson competition (district, city, province and nationwide). Peng (2007) concluded that lesson explaining could promote participants' growth in subject knowledge as well as pedagogical content knowledge.

Recently, explaining problem solving competitions have developed into a popular way of promoting young mathematics teachers' growth. The participant teachers are required to explain a set of interconnected problems with regard to: the background of problems including context, knowledge, and thinking methods; making sense of the problems; explaining methods of solving the problems, extending the problem by varying conditions, results or analogizing thinking methods, and reflecting on critical steps of problem solving and student difficulties (Ye et al. 2011).

2.3.2.3 New Developments

Recently, teaching research activities have evolved into a new phase, school-based study, by adopting the concept of "communities of practice" (Wenger 1998). The school-based study has shifted its foci (Gu 2005): (a) from development of teaching procedural proficiency to building teaching culture and community, (b) from studying of content and pedagogy to studying of students' learning and teachers' behaviors, (c) from perfecting teaching activities to the cultivation of teaching research awareness, (d) from the reflection on limited experience to upgrading education ideas and cultural reconstruction. In school-based study, practicing teachers are expected to experience the entire process of practical problem posing and solving and develop their practical wisdom and theoretical knowledge. Thus, a safe, trustful, and constructive practical community is emphasized so that practicing teachers and experts can freely share their options about improving teaching and student learning rather than critiquing teachers' behaviors.

The development of open lessons includes the cyclical process of collaborative lesson planning, trial teaching, post-lesson reflection, and revision. In "*action education*" (Gu and Wang 2003), a new approach was recommended: teachers are asked to plan a lesson in his/her own way and teach it to find the gap between the vision of teaching and learning in the new curriculum reform, and his/her own actual teaching and student learning. Based on identifying the teacher's gap, the teacher works with the members of TRG to redesign the lesson in alignment with the new curriculum and theories of teaching and learning. The second lesson is intended to bring about improved teaching and help teachers collect evidence of the gap between theoretical visions and actual teaching and student learning. A third lesson is taught so that the teacher can apply the improved practice to focus on the evidence of student learning and its result (Huang and Bao 2006). This is often coined as Chinese lesson study. In addition to similarities shared with the Japanese lesson study in terms of their activity structures, this approach focuses "on both content and pedagogical knowledge and skills, and an open, learner-centered implementation component" (Lerman and Zehetmeier 2008, p. 139).

Parallel Lesson Study (PLS) is an enriched Chinese Lesson Study. Through the process of Chinese Lesson Study, at least two lesson study groups independently develop exemplary lessons of teaching a selected topic. Then, a teaching research activity at the cross-district level is organized and participants in lesson study groups and others are invited to participate in the teaching research activity. A post-lesson meeting focuses on comparing and contrasting the exemplary lessons. Huang et al. (2014) found that practicing teachers could develop their competence in identifying instructional objectives, improving instructional process, selecting and sequencing mathematical tasks, and developing professional vision through participating in a parallel lesson study.

2.3.3 Implementing New Curriculum Training Programs

China has launched its new *Mathematics Curriculum Standard for Compulsory Education Stage* (MOE 2001a) in 2001, and has officially implemented it nationwide since 2010. There are various training programs helping teachers to understand the reform-oriented curriculum and textbooks, and develop their knowledge and skills for implementing the new textbooks. It is required that all teachers attend at least 40 h of training before using the new textbook (MOE 2004). A “cascade model” has been adopted to train teachers for using the reform-oriented curriculum. It started with “seeding” the new idea and strategies of implementing reform-oriented curriculum and textbooks through the training of “trainers and key teachers” at national level, and then training of “local trainers” through national “trainers,” and then the local trainers facilitate the training of classroom teachers (see Huang et al. 2010 for details).

2.3.4 Upgrading Education Degree Programs

There are different channels for unqualified teachers to advance their degrees. Some continuing education colleges at universities have provided programs to attain education degrees through distance education since 2003. In addition to helping teachers upgrade to a required education degree, some master programs or masters in education programs specializing in mathematics education, have been opened in many provinces since 1998. The candidates who complete master programs will get a certificate and can apply for a master’s degree if they pass an English test and thesis defense (Huang et al. 2010).

2.3.5 Training Expert Teacher Programs

Expert teachers refer to those who have an advanced professional title or above, and have played key roles in teaching research activities in their school, district, or city. Expert teachers include *backbone teachers* and *master teachers*. Backbone teachers refer to those who are young with an advanced rank, and are actively involved in various teaching research activities. Master teachers conventionally refer to those who are of higher reputation and play an influential role in a certain region. They have modern education and instructional notions, super practical ability, hold a professional title of exceptional teaching, are educational experts at city level, middle-age subject leaders, or have made exceptional contributions and enjoyed governmental subsidy (Quan 2009).

2.3.5.1 Backbone Teacher Training Program

Ministry of Education launched *backbone teachers* programs (MOE 1999a) to advance the quality of education. The Ministry of Education has taken the responsibility for training 10,000 *backbone teachers* nationwide. Local governments have also made efforts to train *backbone teachers* through raising specific funds. At the national level, this program was organized and implemented by several key normal universities. The courses for backbone teacher training programs include theory and skill (40 %), practice and observation (30 %), education research (30 %) (MOE 2001b). At provincial and municipal levels, the key teacher program was organized in a similar way by local universities or institutes.

2.3.5.2 Master Teacher Training Program

After more than 10 years of training backbone teachers, there are a great number of backbone teachers who have taken leadership in their schools. Some of them have developed as master teachers. To make use of the existing master teachers, and develop more master teachers, training programs have emerged and become popular. These programs are either organized by university and school partner (*master teacher training program*), or are led by a master teacher *master teacher workstation (MTW)*. Master teacher workstations consist of a master teacher (recognized and conferred by Provincial education authority) and several backbone teachers (recommended by local schools).

Although there is great variation in master teacher workstations, there are three essential commonalities (Quan 2009): the master teacher leads the practical community, all members of the community share common goals, and members have an identity of ownership in the community. The major activities in a MTW include: (1) master-led activities (master demonstrates teaching, master presentation, master comments on lessons), (2) collaborative teaching research (evaluation of classroom

teaching, examining student and teacher learning through surveys and interviews; classroom observation across subjects; using online platform to share and collaborate); (3) reading and reflection (reading professional articles and books, and reflecting and sharing what they read, teach, and observe), and (4) project-driven activities (differentiated development plan, exploring specific tasks or projects) (Quan 2009). Li et al. (2011b) examined a MTW focusing on elementary mathematics teachers at the province level, and found that the MTW can help participating teachers develop a deeper understanding of mathematics and pedagogical content, and mathematics and its structure in textbooks. Huang and Huang (in press) described how a MTW helped an experienced teacher to develop a problem posing-based teaching approach from initial experience, via, intended exploration of effective strategies in reviews, and continued exploration of the teaching approach in mathematic teaching in general.

Some universities initiate (work with master teachers at practicum partner schools) master teacher training programs. Take a high school mathematics master teacher training program organized by a Normal University in southeastern China for example. The training program consists of five models: (1) theory learning (theories of mathematics learning; reform-oriented models of mathematics teaching, mathematics curriculum), (2) practical instruction, (3) study abroad; (4) field investigation in other provinces; (5) demonstrating teaching; (6) research projects; (7) demonstrating teaching in rural areas; (8) accomplishment demonstration (1200 h in total).

2.4 Conclusion and Discussion

2.4.1 Summary

The systematic ranking promotion system and hierarchical teaching research system are two fundamental infrastructures for supporting teachers' professional development. Li et al. (2011a, b) explained why this ranking system works in China from political, academic, and cultural perspectives. From a political perspective, this system provides a bottom-up, manageable mechanism for teachers to pursue higher professional ranks with an increase of benefits. From an academic perspective, the ranking system specifies what professional competences are needed at each rank so that teachers know what they need to improve in order to get a promotion. For a cultural perspective, teachers get used to getting promotions through examinations and being analyzed in public. Teachers respect senior or master teachers and are willing to learn from others, particularly knowledgeable master teachers.

We further synthesize the trajectory of teachers' growth as follows (Fig. 2.1): Novice teachers typically possess strong subject knowledge through teacher preparation programs. With the support of one-to-one mentoring practice, novice teachers can familiarize themselves with teaching routines and master basic teaching skills (lesson plan, implementation, and evaluation) smoothly and quickly.

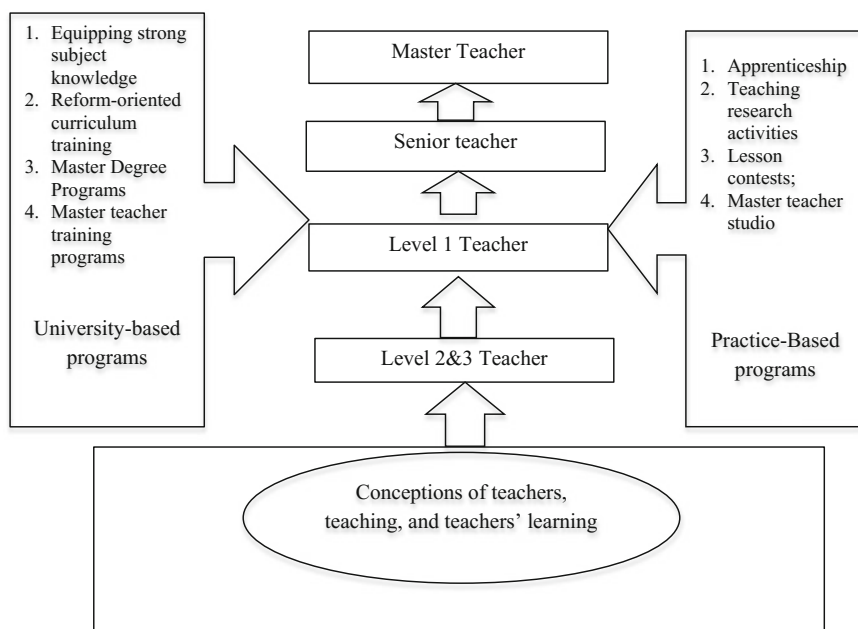


Fig. 2.1 A hybrid system of teacher professional development in China

When novice teachers become confident in teaching (level 2 and 3), various teaching research activities help them further develop their knowledge and skills for teaching and ability in conducting teaching research activities. As a result, some teachers get promoted as qualified/competent teachers (level 1). After that, teachers can further develop and demonstrate their professional competence through winning various contests (e.g., teaching lessons, explaining lessons or explaining problem solving) and doing teaching research projects. Thus, some of them could move up to be experts (senior level). Senior teachers have to take responsibility for mentoring young teachers. However, they can further develop to be *master teachers* (*full-senior*) in order to maximize their roles in mentoring other teachers, implementing new curricula and conducting teaching research on a large scale. The master teacher workstation and training programs meet such needs of teacher professional development.

2.4.2 Discussion

This well-structured, institutionalized teacher professional development system is deeply rooted in the Chinese conception of teachers, teaching, and teacher development. As argued by Leung (2003), emphasizing the subject knowledge of teachers is rooted in the conceptions of teachers and normal universities in China.

The graduates from normal universities (teachers' model) should be models for their students with regard to moral and academic aspects. It is necessary for teachers to have sound subject knowledge. Teaching in China is a publicly scrutinized enterprise (Li and Huang 2008). Giving open lessons, observing lessons, evaluating lessons, and reflecting on lesson are common components of teaching research activities. All teaching research activities focus on addressing teachers' practical concerns, solving their daily problems, and pursuing exemplary lessons. In Chinese culture, it is believed that teachers can develop their knowledge for teaching "from examples and by doing" (Li et al. 2011a, b). Respecting seniors and learning from others, as indicated by "there are tutors among three people" (Confucian, *The Analects*), is a traditional trait. It is also believed that there are some good teaching models, which can be adapted (Cheng 2004). Thus, watching others' teaching and modeling good lessons are legitimate ways to develop teacher professional knowledge. Moreover, the ranking and promoting system provides mechanisms and incentive for teachers' continuous growth, while teaching research activities provide supportive platform for teachers to pursue their excellence.

Like teaching, teacher learning is a cultural activity (Stigler and Hiebert 1999). When other education systems reflect on what could be learned from the practices in China, it is important to identify their cultural values about teaching and teacher learning.

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