Chapter 15
Facilitating Professional Growth of Taiwanese In-service Mathematics Teachers Through an Innovative School-Based Program

Fou-Lai Lin, Hui-Yu Hsu and Jian-Cheng Chen

Abstract The chapter begins with the present challenges that mathematics educators in Taiwan are facing. It outlines the hierarchical structure of in-service teacher development and highlights how the top-down approach often adopted may not address the needs of classroom teachers. The authors of the chapter next describe an innovative school-based program, Lighten-up School-Based Program (LUSBP), they initiated for facilitating professional growth of mathematics teachers in Taiwan. The core for LUSBP is that all tiers of educators, teachers, and students learn through active participation whilst interacting with each other. The project employs a design-based approach with teachers as designers who learn from the process of creating tasks, enacting tasks with classroom students, and revising tasks based on students’ learning. The school-based model enables the creation of a friendly learning environment where teachers take it for granted to make changes and are willing to share their experiences with one another. The outcomes of LUSBP are positive and hold promise for the future.

Keywords Professional growth · In-service mathematics teachers · School-based professional development program · Design-based professional development program
15.1 Main Challenge in Taiwan Mathematics Education

Students’ performance on large-scale mathematics assessments in East Asian countries can be generally categorized into two contrasting groups (Mullis et al. 2008; Mullis et al. 2012; OECD 2005). One group comprising countries such as Taiwan, Hong Kong, Korea, and Singapore has consistently ranked on top on those assessments. However, students in this group usually have low confidence in and keep negative attitude towards the learning of mathematics. The other contrasting group comprising countries such as Thailand, Indonesia, Philippines, and Malaysia has students with high confidence and positive attitude but their students performed much lower than those in the first group. While mathematics education aims to nurture students in both mathematics competence and positive learning attitude, each group of countries has to face their specific educational challenges.

The challenges in Taiwan involving the prevailing phenomenon of students’ low confidence in and negative learning attitudes towards mathematics are strongly related to the examination culture. Lin and Tsao (1999) pointed out that examination-driven instruction often asks students to practice as many examples as possible and does not undertake any explorations or extensions because of the time consideration. The drill and routine practices lead to memorization and decrease students’ interest in learning mathematics. Lin (2009) further indicated that Taiwanese teachers often think that teacher-centered instruction (talk and chalk) is necessary for successful learning, such an instructional situation results in the lack of opportunities for students to think mathematics actively. Examination-driven environment is also very likely to influence novice teachers in shaping their teaching styles at the beginning of their careers in schools.

We believe that curiosity and the ability to stand for a proposition are the key to the succession of mathematics learning. It is important for students to learn how to generate examples in dual relation with mathematics concepts and mathematics results (Michener 1978). In this regard, Taiwan Central Counseling Team (CCT) proposed a nation-wide professional development project, namely Lighten-Up School-Based Program (LUSBP), using a design-based approach with the aim to facilitate in-service mathematics teachers to improve their teaching and promote students’ active thinking and learning power. Here, learning power refers to the supple and nimble minds so that students will be able to learn whatever they need to (Claxton 2002).

15.2 Central Counseling Team (CCT) in Taiwan

Taiwanese official teacher counseling organization mainly involves two hierarchical systems: Central Counseling Team (CCT) and Local Counseling Teams (LCT). CCT is affiliated to Ministry of Education, whereas LCT is affiliated to local administrative divisions (e.g., municipality and county). For CCT, Ministry of Education (MoE) (2008) clearly stated the purposes of establishing the system are...
(1) to assist the propaganda and implementation of policies related to curriculum and instruction; (2) to promote professional growth of teachers and their knowledge for teaching; (3) to enhance the quality of classroom teaching and student learning; and (4) to construct a curriculum development model based on the integration of research and practice as well as to build up a tertiary instruction counseling system.

To achieve those purposes, the approach that CCT from 2002 to 2011 usually employed was to hold professional development workshops with the topics that were either new ideas learned from literature (e.g., collaborative learning) or those that have the potential to overcome the challenges specific to Taiwan education (e.g., examination-driven instruction). CCT invited experienced educators, usually experienced mathematics teacher educator-researchers (MTE-Rs), to implement the workshops and required CCT teacher members or those selected from LCT to participate in. The participating CCT and LCT teachers trained then become seeded teachers who can in turn be the educators or mentor teachers to help local school teachers learn the new ideas or policies. In this regard, CCT plays an intermediate role of coordinating and connecting between MoE and LCT, and supports LCT to facilitate school teachers to adopt the new policies and implement new instructional ideas in their classrooms.

The intermediate role of CCT for coordination and connection is important. However, the tertiary instruction counseling system from MoE, CCT, LCT, then to school teachers very likely creates educative challenges. The main challenge has to do with the tertiary instruction counseling system which is more inclined to a top-down model where CCT followed policies and then determined the topics that school teachers need to learn. Then, the sequential transformation from MoE, CCT, LCT, and then to school teachers makes it possible that school teachers are passive receivers, who inactively receive the knowledge and policies that MoE and CCT attempt to convey. Recognizing that the transfer of knowledge from educators, teachers, to students in professional development is not a linear and one-way process in which the solutions to problems encountered in teaching and learning can be directly obtained. This transferring process is complex, cyclic, and sophisticated; involving interplays with multiple tiers of participants (Lesh 2003; Lesh et al. 2007; Lesh and Kelly 2000). Thus, it is highly possible that the top-down approach leads school teachers think that they can know the solutions from educators instead of formulating instructional strategies specific to their pedagogical challenges themselves. A notable example for the top-down approach in Taiwan is the implementation of Constructivism Teaching Approach around 2000, in that case classroom teachers only knew the general ideas of the new teaching approach from the one-shot workshops arranged by MoE. However, teachers were lack of competence of transforming the learned ideas into actual classroom teaching. Another challenge may be due to the way of assigning one teacher from each individual school to participate in professional development workshops. Even the assigned teachers are willing to change their classroom teaching based on the new ideas learned from the workshops, they may not be able to convince other school teachers to do so. Also the challenge can be related to the knowledgeableability and identity of LCT in facilitating school teachers to solve a diversity of pedagogical challenges.
encountered. All of those challenges can downplay the effectiveness and efficiency of professional development workshops and result in limited professional changes of in-service teachers.

Additionally, the evaluation for professional development workshops often used quantitative reports. For example, how many workshops have been held each semester? How many times do LCT members consult with school teachers? Fundamental issues regarding teacher growth, the improvement of classroom teaching, and students’ learning quality may not be revealed by this evaluation approach accordingly. In order to solve the challenges mentioned previously, we (the authors of this chapter) proposed an innovative project for facilitating professional growth of in-service mathematics teachers. The project is described in the following sections.

15.3 Innovative Professional Development Program: Lighten-up School-Based Program (LUSBP)

The conceptualization of the LUSBP is shaped by three main aspects, namely research experiences, school-based model and active participation of schools, and co-operation of university faculties in Taiwan. In the following sections we elaborate on each of them.

15.3.1 Research Experiences

15.3.1.1 Experiences with the Implementation of Design-Based Professional Development Workshops for Experienced Mathematics Teachers

The main foundation that supports us to set up the nation-wide professional development project is our experiences with the implementation of design-based professional development workshops for experienced mathematics teachers for three years. The aim for the workshops is to enhance active learning: not only for students to learn mathematics actively, but also for teachers and the educators to make changes for enhancing their pedagogical power and educative power respectively. Of importance is to create a learning environment where students can experience the essence of mathematics learning. The essence of mathematics learning is rooted in the well-organized body of mathematics knowledge, involving enculturation of students’ minds through environmental activities (e.g., explaining) (Bishop 1991), perception of how mathematics is developed and formulated (Lakatos 1976), and the understanding of the origins of mathematics from an epistemological perspective (Freudenthal 1983). The core idea is to enable students to observe and derive crucial mathematics ideas and meaning from reality, and develop the mathematics sense to solve problems in- and out-of-mathematics.
The rationale for the design-based professional development is the design research paradigm (Cobb et al. 2003). To implement design approach, we employed a three-layer structure including grand theory, intermediate framework, and design tool (Gravemeijer 1994; Ruthven et al. 2009). The latter two serve to coordinate and contextualize the theoretical insights from grand theories about the epistemological and cognitive perspectives into the designs and the study of their operations. In order to facilitate teachers to design tasks, we also propose three entries including misconceptions, propositions in school mathematics, and mathematical facts; by which teachers can much easier initiate a plan for the design. Five researchers including the authors played roles of designers and critical commentators for arranging workshops that better facilitate professional growth of experienced teachers through a task-design approach. The researchers chose conjecturing and diagnostic teaching as the themes for the workshops as they, on the one hand, can easier motivate students to think mathematics actively, and, on the other hand, can detect students’ learning problems and then design tasks that can solve the problems accordingly.

Being task designers, teachers in the professional development workshops have opportunities to intensely explore curriculum materials and students’ learning as well as to incorporate professional development materials into their designs; all of which become important sources for improving their knowledge for teaching. To help teachers design tasks, relevant theories and strategies with corresponding examples were elaborated. During the workshops, teachers were required to initiate tasks, present their designs in professional development for obtaining feedback from educators and peer teachers, enact the designs with students, and revise the work accordingly. The whole process offered participating teachers opportunities to detect and challenge their individual pedagogical problems. The professional development programs were led by the first author, an experienced educator who mastered in both research in mathematics education and teaching practices in classrooms. Because of his expertise in both research and teaching, the educator was able to elaborate the research and theories in association with student cognition and provide directions for the refinement of tasks.

The experiences with implementation of the professional development workshops for three years enable us to propose three keys that have great impact on the succession of teachers’ growth in profession.

(i) Getting started: Formulating pedagogical problems by teachers

Cooney (1994) reported that teachers may not see any conflicts in their teaching and call for the attention to how teachers formulate and then solve their pedagogical problems for the growth in profession. Cooney stated the notion of pedagogical power, indicating that it involves recognizing conditions and constraints of classroom situations, assessing the consequences of possible actions, and then determining what actions are the best for the particular situations in classroom teaching. As change of teachers must be “motivated by some need to adopt or engage or reject” (Reid and Zack 2010, p. 372), teachers’ extrinsic and intrinsic motivation that triggers them to get started in formulating pedagogical problems is of
importance. After formulating pedagogical problems, the follow-up stage is how teachers come up with plan to challenge their pedagogical problems.

(ii) Coordination as mechanism for teacher growth in profession

Reflection and enactment are currently the key trust in teacher education (Jaworski 1993; Smyth 1989). We propose coordination mechanism and argue that it can clearly identify the quality of teachers’ reflection and enactment in terms of how they construct novelty for their professional growth. Particularly, we concern what sources of information that teachers perceive and reflect in professional communities, and how they coordinate the multiple sources and then instigate the follow-up actions accordingly. We also identify the crucial components involved in coordination mechanism. The elaboration of the mechanism with examples will be published soon by Lin, Hsu, Yang, and Chen.

(iii) Elaborating theoretical ideas at proper moments and in proper ways

We recognize the importance of theoretical ideas for teachers to structure their teaching and to identify students’ learning difficulties. However, theories are not usually appreciated by school teachers as they may directly respond that theories or principles are far away from their teaching practices and argued that they only want something that can be directly used in their teaching without any further work. Our research experiences show that elaborating theoretical ideas for teachers necessities educators’ power for communicating with educative phenomenology, reasoning onto emergent models and theories about educative phenomenology, and maintaining a dialectical connection between practice and research (Yang et al. 2015). Through supporting and challenging, educators facilitate teachers to understand the meaning of these theoretical ideas and their contributions to classroom teaching at proper moments and in proper ways.

15.3.1.2 Experiences with an Integrated Research Project

Another important foundation for LUSBP is a three-year design-based research project founded by Taiwan national science council for professional development with seven sub-projects in seven universities. After implementing design-based professional development workshops for three years, the first author launched the research project and called for cooperation in Taiwan. As a result, seven university faculties who master in professional development and have different research expertise participated in the project. Carrying out the integrated research project gives us confidence in initiating and implementing LUSBP. One main reason is that those faculties participating in the project are also the MTE-Rs for LUSBP. Another is that the execution of the project offers us the opportunity to comprehensively reflect the nuances that are keys to the succession of a nation-wide program.
15.3.2 School-Based Model and Active Participation of Schools

It is important that the professional development workshops are arranged on a school basis rather than for the individual teacher account. Each school has the responsibility to create a friendly learning environment and develop the norm in which teachers can take it for granted to make changes and are willing to share their teaching and learning experiences with one another. Second, professional development should be organized in a long-term stance because teachers’ professional growth takes time (Clarke and Hollingsworth 2002; Guskey 1986). Also of importance is the continuing focus on a specific theme for each school. Our experiences in implementing professional development for experienced mathematics teachers show that teachers’ quantum-jump of professional growth has to take at least two or three years. Thus, the deficit model of one-shot workshops aiming at teacher mastery of prescribed skills and knowledge should be excluded.

Another key to LUSBP is that schools actively applied for the program, which reveals the intention of school teachers who expect to make changes to enhance their pedagogical power.

15.3.3 Cooperation of University Faculties in Taiwan

Another innovation of the program is to have about 90% university faculties who have mathematics education expertise participate in LUSBP and lead the school-based professional development workshops.

15.4 Organization of LUSBP

LUSBP was initiated by the first author, the director of CCT. LUSBP started from 2012 and keeps running until now. Each semester, school teachers participating in LUSBP have to attend five or six sessions, each of which lasts for three hours. Table 15.1 is the summary of number of elementary and middle schools applied for LUSBP till the second semester of 2016 as well as the number of mathematics educators, most of which are MTE-Rs, involved in the project.

Those schools participated in LUSBP located in different municipalities and counties around Taiwan. The amount of schools and educators engaged in the program is an innovation in Taiwan mathematics education.

Another innovation for LUSBP is to include a variety of themes: conjecturing, modeling, reading comprehension, conceptual diagnostic teaching, inquiring, assessment for mathematics literacy, and teaching with DGS supports. As the first author has been the chair of Department of International Cooperation and Science...
Table 15.1  Summary of schools participated in LUSBP

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of elementary schools</td>
<td>30</td>
<td>29</td>
<td>24</td>
<td>41</td>
<td>82</td>
<td>94</td>
<td>95</td>
</tr>
<tr>
<td>Number of middle schools</td>
<td>22</td>
<td>34</td>
<td>35</td>
<td>27</td>
<td>34</td>
<td>47</td>
<td>19</td>
</tr>
<tr>
<td>Sum</td>
<td>52</td>
<td>63</td>
<td>59</td>
<td>68</td>
<td>116</td>
<td>141</td>
<td>114</td>
</tr>
<tr>
<td>Number of educators</td>
<td>47</td>
<td>51</td>
<td>40</td>
<td>52</td>
<td>60</td>
<td>58</td>
<td>67</td>
</tr>
</tbody>
</table>
Education at Ministry of Science and Technology, he has well understanding of individual mathematics education faculty in terms of their research expertise around Taiwan. The understanding enables him to formulate the themes with the aim to well connect between research and practices. The underlying rationale for the themes is to create opportunities for Taiwanese students to learn mathematics in a more active way.

Before running LUSBP, we also invited experienced MTE-Rs to discuss the curriculum materials with correspondence to each theme and to structure the session agenda. We then open the program for schools and encourage them to select a theme which meets their school’s need. Our experiences of implementing LUSBP for seven semesters also reveal that a high portion of schools who continued participating in LUSBP tended to change the learning themes from semester to semester. After schools determined their professional development themes, faculties who were mastered at or interested in the selected themes were assigned accordingly. Similar to our design-based workshops, LUSBP also asked teachers to initiate tasks, present their designs for obtaining feedback from educators and peer teachers, enact the designs with students, and revise the work accordingly. The whole process offered school teachers opportunities to detect and challenge their individual pedagogical problems.

Rather than evaluating LUSBP by quantitative report, each semester we hold a symposium and invite each school to share their learning and challenges.

15.5 The Learning of Students, Teachers, and Educators

The effectiveness and efficiency of professional development heavily relies on the quality of the interactions among tiers of participants including educators, teachers, and students. Of importance is that not only students but also teachers and educators can recognize their role as learners involved in the professional settings. Lesh and Kelly (2000), using mathematical modeling as an example, highlighted the importance of involving different tiers of participants who cooperate in an interactive nature to solve problems encountered in classrooms.

15.5.1 The Learning of Teachers and Students

The effectiveness and efficiency of individual school participating in LUSBP is carefully detailed in another chapter of this book, titled as “School-based in-service mathematics teachers’ professional development: The approach of diagnostic conjecturing activities designing”. Generally speaking, teachers’ learning in LUSBP involves two aspects. One occurs in professional development workshops; and the other happens during the interactions with other school teachers and educators in symposiums. Teachers’ change, especially the change in belief, usually
involves a long-term journey. Although LUSBP schools are voluntary to apply the program, we still see a number of teachers have doubts of the values of the program at the beginning participation stage. For example, teachers may say that they do not know what they can learn from the program. Even though the teachers saw the differences between their teaching and others (e.g., student-centered teaching approach), they may still keep the doubts in mind. Those teachers usually are satisfied with their classroom teaching and think that they know their students well. One crucial turning point for the teachers to make change is to design and test learning activities (which contained tasks). Through designing and testing, teachers have opportunities to create or revise instructional activities that they have not implemented previously, thus creating opportunities for them to learn from their students. Another crucial turning point for the teachers can be the responses from their students, especially those they do not know previously.

There are two main aspects of teacher learning in this project. The first aspect involves teachers’ learning from changing their classroom teaching for providing students more opportunities to think and construct mathematics actively. For example, teachers can try to change the teaching entry from posing a true propositions or concepts to false ones. Teachers can also change the teaching strategies that involve students engaging in enquiry-based learning activities. It is the importance of the change of teachers’ roles from transmitter of knowledge to the facilitator of learning. The second aspect involves teachers’ learning from enhancing the understanding of student learning. Teacher can learn from communication of students’ specific performance. Teacher also can learn from reasoning students’ learning difficulties and formulate the underlying reasons that constitute the difficulties. Also can be that teacher learn from connecting students’ various responses.

The symposiums also offer teachers opportunities to learn from other school teachers and educators. Symposia allow teachers to share the challenges encountered and discuss the possible strategies that can be used to overcome the challenges. Through participating in the LUSBP symposium, teachers can learn by observing how other schools implement the professional development workshops. They also can observe tasks designed by other teachers and then adopt and modify the tasks for their own use. Symposia also allow teachers to discuss the effectiveness and efficiency of the ways of facilitating teacher learning so that the program can be improved accordingly.

15.5.2 The Learning of Educators

Educators’ learning is another key of LUSBP. Educator’s learning also plays crucial role of determining the effectiveness and efficiency of professional development programs. As Zaslavsky and Leikin (2004) stated that educators, similar to mathematics teachers, make professional growth through the practices involving research and implementation of professional development workshops with teachers.
More than that, we stated that it is crucial to create an environment where educators, including those university faculties, can learn from one another. To this end, we initiated a professional development forum for educators, most of which are MTE-Rs, after implementing LUSBP for a semester. This was due to the tensions encountered by educators when they facilitate teacher growth in professional development workshops. One tension has to do with the issue about utility of theory as teachers usually expressed that theory is not useful to their teaching practice. Another tension involves the identities of in-service teachers in relation to educators in professional development workshops. For example, some in-service teachers may attend workshops only for knowing if there’s something new that they can directly use in their classroom. In this regard, they are passive receivers and usually refuse to involve in task design. The third is the tension related to teachers’ vulnerability. Teachers may feel criticized and vulnerable when they receive suggestions and comments from peer teachers and the educators. In this situation, it is likely that teachers become too guarded to follow professional development agenda.

Those tensions described above became the discussion issues for the forum for the educators. The forum offered educators opportunities to express their perspectives related to the tensions and the ways that they dealt with them. Before educators discussed the issues in groups, some educators and experienced mathematics teachers were invited to share their experiences and perspectives. The sharing activities by the educators and experienced mathematics teachers helped other educators make sense of the tensions and provoke their memory of prior experiences related to the tensions. In addition to the discussions with the tensions, several educators, especially those experienced educators, were also invited to share how they implemented professional development with different themes initiated originally. The discussions among the educators and the presentation related to different themes were necessary to identify educators’ initial, perhaps reflective, perspectives with respect to the tensions; which consequently affect their decisions and practices in facilitating teacher growth.

A total of forty-two educators, most of which are also faculties teaching at universities, participated in the forum. Most of the educators have Ph.D. degree in mathematics education. Some others major in mathematics and teach courses related to mathematics education at university level or have experiences with implementing professional development workshops for mathematics in-service teachers. Additionally, nine experienced mathematics teachers affiliated to CCT also participated in the forum. Those teachers allowed the educators to know more about the tensions from teachers’ perspectives.

Taking an example involving the tension of elaborating theories and principles for participating teachers, we note that the tension is strongly related to teachers’ perspectives on the utility of theory. We analyzed the data collected from the professional development workshop for educators and categorized educators’ perspectives on utility of theory into three main types including concerns about meaning of theory; concerns about application of theory; and concerns about meta-coordination of theory. Details of teachers’ perspectives on utility of theory can be seen in the forthcoming paper written by Lin et al. (In Submission).
15.6 Concluding Remark

Design is the core of solving educational problems; not only because it can create a diversity of curricular materials to enhance students’ learning of mathematics but also a tool to facilitate professional growth of teachers and educators through the cycling process of creating tasks, enacting tasks with students, and then revising the tasks based on the reflection on student learning phenomenon. Another core for professional development is that educators, teachers, and students are all active learners; each of which takes his/her responsibility and work for his/her own learning. The ground-based and cooperation among three tiers of participants make it possible for the improvement of mathematics education in Taiwan and enable students with mathematics literacy and positive learning attitudes.

To this end, this chapter presents a nation-wide professional development program, namely LUSBP, in Taiwan that is established based on several innovations: (1) a relative high portion of schools and roughly 90% of faculties who are mastered in mathematics education participate in the project; (2) school-based arrangement which bridges the gap between the research and practice as well as creates the environment where school teachers can learn from one another; (3) the implementation of teacher-as-designer approach; (4) enactment with a variety of themes under the core of students’ active thinking; (5) the implementation of professional development workshop for educators to learn.

Our implementation of LUSBP for semesters shows that school-based professional development can facilitate teachers’ growth through a design-based approach. Teachers’ reflections highlight the value of the project as it can lighten up their minds and competences for better mathematics teaching and learning.

While recognizing the power of this project to teacher growth in profession, we also noticed the tensions faced by educators. As educators recognized the responsibilities to facilitate teachers’ growth in profession, they encountered challenges and tensions due to teachers’ different identities in the professional development program, the difficulty in elaborating theories and principles for teachers, and the vulnerable characteristics of teachers; which in turn may hinder the facilitation of teachers’ professional growth. To solve those tensions encountered by educators, we held a professional development workshop where the participating educators can share their educative challenges and strategies with one another.

For teachers, they also face the challenges and tensions with respect to designing, teaching and students’ learning. Designing involves teachers’ confidence in creating the tasks, some teachers may think designing is the jobs of publishers but not theirs; thus refusing to participate in designing. The attitude can constrain those teachers’ learning. Regarding the challenges related to teaching, it is about the struggle between content-oriented and student-centered. Taiwanese teachers usually concern how mathematical content can be successfully acquired by students instead of the ways that students participate in learning mathematics. As to students’ learning, teaching for different levels/populations of students to promote their active thinking is the key for consideration. Another tension is about how to structure the
tasks and manage the openness of the problems so that students know how to do it in an active way. Those challenges and tensions require long-term cooperation between educators and teachers in a reciprocal relationship for self-understanding and re-conceptualization of mathematics teaching and professional development (Jaworski 2001).

References


