Lin, P. J. (2003). Supporting teachers' learning in primary mathematics teacher education. Paper presented at the *Taiwan-The Netherlands Seminar: Eastern and Western Views on Science and Mathematics Teacher Education: Difference and Similarities*. November 2-6, The Netherlands.

SUPPORTING TEACHERS' LEARNING IN PRIMARY MATHEMATICS TEACHER EDUCATION

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Abstract

Taiwan's mathematics curriculum has been undergone three reforms in the last three decades. The implementation of the reforms into classroom increases the complexity of teaching. As a result, teachers are expected differently under the three reforms. Due to the roles teachers playing differently under the reforms, the approaches of teachers' development are designed in different. This paper begins with the expectations for teachers under the three reforms. It continues with a brief review of the studies on teacher professional development program that was designed to support teachers in implementing the standards into classroom. The second section is devoted to the theoretical framework of a teachers' development program I investigate in recent six years through two successive three-year research projects sponsored by National Science Council of Taiwan. The two projects have the same goals but with different supports for teachers, which are determined by the impact of the two recent reforms, 1993 version and 2001 version.

The theoretical framework of the program includes the goals and the supports for teachers. The goals referring to what teachers need in order to fit the needs of the reform. Three domains knowledge including mathematics content, pedagogy, and students' cognition, and reflection are considered as four outcomes to orient teachers to grow. The supports for teachers consist of six learning strategies and two learning contexts. The design of assessment tasks along with students' responses to the tasks, one of the needed supports for teachers investigated in the first three-year research project are reported here only. A cooperatively professional team consisting of the researcher and same-grade teachers in a school was set up as a learning context for supporting teachers in learning assessment integral to instruction. Besides, classrooms were the primary learning context. Within each learning context, social interaction, cognitive conflicts, and reflection are considered as three mechanisms resulting in teachers' knowledge growth of assessment and students' learning. The dimensions of teachers' professional development identified in the program and suggestions to research on teacher professional program are proposed at the end of the paper.

Key words: professional development, in-service teachers, curriculum reform

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Introduction

Reacting to societal pressures and drastic changes in the educational conditions of Taiwan, the curriculum standards issued by the Ministry of Education (1993) articulate a national vision of what constitutes reformed mathematics teaching and learning. The standards-oriented teaching has shifted its focus toward learner-centered away from teacher-centered. The implementation of the standards into classroom increases the complexity of mathematics teaching. As a result, reformed mathematics curriculum requires substantial new experience and needed supports on the part of teachers. In recent years, the growing body of research on teacher learning and change has provided insights into the kinds of learning that are likely to support significant shifts in mathematics teaching (Chung, 1998; Lin, 1999, 2003).

To implement curriculum into classroom practices, a school-based curriculum investigation approach supports teachers moving toward the vision espoused by the standards and promoting teachers' growth (Chung, 1999). In Taiwan, field-testing curriculum is commonly in one or two classes in each school that was invited to test the curricular materials. At the beginning of the field test, all 6 first-grade classes in one of the schools carried out the curricular draft. In the second year, all 6 second-grade classes and new first graders used the draft. This pattern was repeated as the year progressed. Offering the same grade teachers with didactical dialogues was a kernel part of enhancing teachers' knowledge growth. In sharing their experiences, the second-grade teachers with an additional year of experiencing the draft assisted the new first-grade teachers. The approach suggested that the degree of teachers' growth depends on the years they investigated the curricular draft. Curriculum investigation is one of the powerful approaches to help teachers move close to the focus espoused by the standards-oriented curriculum.

The author develops a series of studies on teacher professional development program that supports teachers learn to develop deep understandings of students' mathematical thinking as another approach of assisting teachers in implementing the tenet of the reformed curriculum into classrooms. The paper will give you a brief review of the theoretical framework of in-service teacher

professional program that was developed through two successive three-year research projects sponsored by National Science Council of Taiwan. The third year of the second research project is ongoing. These two research projects have the same goal but with different supports for teachers learn to teach which are determined by the impact of two current curriculum reforms. To help you understand the rationale of developing in-service teachers education program referred to the paper, I start with the expectation for teachers under three curriculum reforms of Taiwan in the last three decades.

Expectations for Teachers under Three Curriculum Reforms

Two former curriculum reforms: 1975 version and 1993 version

Taiwan's mathematics curriculum has been undergone three reforms in the last three decades. These reforms include the Curriculum Standards for Elementary Mathematics (CSEM) issued in 1975, which was re-issued in 1993, implemented in 1996, and the Nine-Year School Curriculum (NYSC) issued in 1998 (MET, 1998), implemented in 2001, and reissued in 2003. The first three-year research project was designed to help teachers implementing curriculum of the 1996 version into classroom practices and the second three-year research project was for 2001 version.

The official unified mathematics textbook has been used by elementary schools all over Taiwan since the Ministry of Education of Taiwan issued the CSEM in 1975. The official unified textbook used for the nearly three preceding decades has been replaced by the "approved textbook" and approved by review committees from the Ministry of Education since 1996. Traditionally, most teachers began teaching with the textbook and teacher's guide from the beginning of each semester, following it lesson by lesson. Their focus was helping students pass one examination after another and, as a result, teachers seldom took the educational needs of individual students into account. Using the official unified textbook left teachers unable to design and develop curriculum.

The philosophy underpinning the 1993 version of the mathematics curriculum reflects that knowledge should be constructed actively rather than passively. As such, mathematics classrooms are expected to become as mathematical communities away from classroom as simply a collection of individuals. For teachers, they needed to face a complete paradigm shift.

Current curriculum reform: 2001 version

Some of the basic educational problems in Taiwan throughout the last 50 years include educational rigidity and idleness, gap between school and society, educational inequality, excessive focus on examinations, lack of versatility in teacher education, and inefficiency in utilizing educational resources.

Due to these persisting problems, the government desperately needs to reform its educational system. As a step in this process, teachers need to face another curricular

reform only five years after the previous reform in 1996. The curriculum NYSC in 2001, one of the largest educational reforms up to date, accentuates on three major areas: stressing basic ability as opposed to subject knowledge, integration of learning fields, and designing of school based curriculum. The framework of the 2001 version is stated as the indicators of competency at each level band instead of mathematics contents to be learned. What mathematics contents choose to learn at each level band becomes as a critical issue among the curricular designers and classroom teachers. In decades past, teachers lacked active exploration and professional dialogues because school meetings were the affairs of administration.

Under the NYSC, one new expectation placed on primary school teachers shifts toward designer of school-based curriculum away from executioner of the official unified textbook. To effectively deal with the school-based curriculum design, teachers must rethink the content of curriculum, its organization, and the basic instructional approach to improve students' mathematics power. Traditionally, the teacher has played a passive role in this process. Speakers in workshops usually offered theoretically oriented teaching material and teaching demonstrations that, unfortunately, did not fully address the needs of day-to-day teaching practice. As a result, teachers often did not benefit from what these workshops and institutes intended to provide. Moreover, teachers' participation in workshops tended to serve the purpose of gaining credits for attending rather than truly reinforcing professional growth.

If the implementation of the NYSC is to be effective, the meaning and means of professional development should not be restricted to such narrow conceptualization. Activities for professional development must be more than workshops or institutes. Instead, teachers must be given to learn to transform their thinking into actions and, in turn, reflect on these actions.

Theoretical Framework in the Reported Teacher Professional Program

The goals of the reported teacher education program include 1) enhancing the rethinking of mathematics teaching in classrooms; 2) fostering teachers' awareness of children's learning; 3) supporting teachers as they begin to put into practice their new vision of a learner-centered approach to teaching mathematics; and 4) improving teachers' reflective ability. Social constructivism dealing with the construction of knowledge through interactions between humans and social worlds is drawn on as the basis for the professional program. Thus, within the two three-year research projects, a collaborative school-based professional team consisting of the researcher and primary school teachers from a school was set up for providing teachers with professional dialogues based on classroom practices. Reflection, social interaction, and cognitive conflict are considered as three mechanisms of enhancing teachers' knowledge growth. Mathematics classrooms and school-based professional team are two social

contexts for teachers supporting mutually in the teacher education program.

The goals of the teacher education program

The theoretical framework of the research on developing a teacher education program consists of learning goals, learning strategies, and learning context. The interventions of the program are given in Figure 1.

Figure 1 shows that learning goals refer to increase teachers' knowledge of mathematics content, pedagogical content knowledge, and learners' cognitions in mathematics. Critical reflection is also considered as a goal to be learned in the program. Teachers' classroom behaviors are derived at least from the interaction among these three knowledge domains (Fennema & Franke, 1992). Moreover, Figure 1 reveals the area of each knowledge domain unequally at each grade level. At the primary level, learners' cognitions including knowing how students think and learn in specific mathematics contents is heavily drawn attention by school teachers involved in the program. On the contrary, the teachers at upper grade level drew more attentions to mathematics contents than those at lower grade level. The complexity of mathematics contents increased by grade level makes it more difficult for primary school teachers.

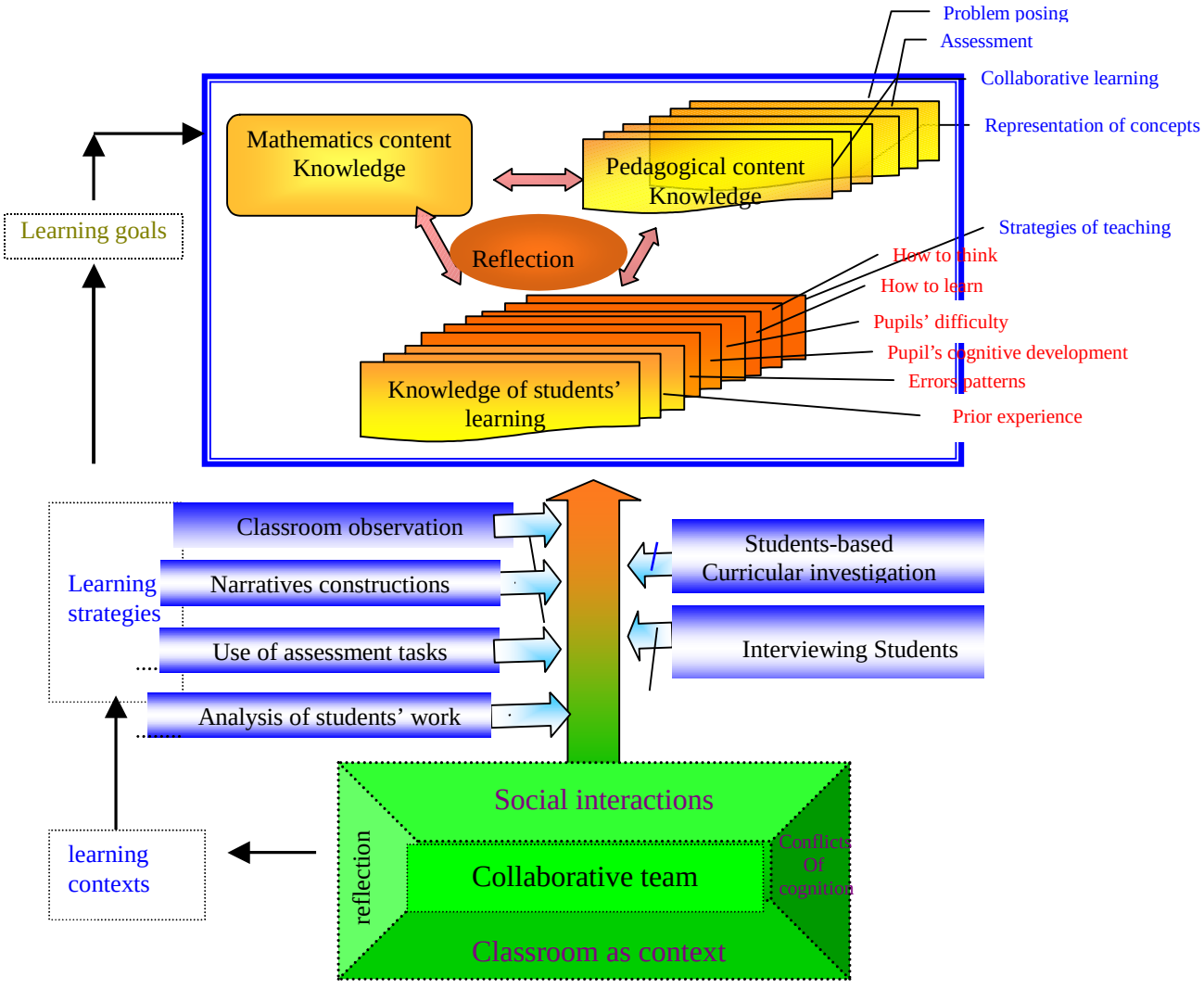


Figure 1 Theoretical Framework of a Teacher Professional Program

Supports for teachers learn to teach

Six tasks were explored in the two three-year research projects as the supports of enhancing teachers' professional development. The six learning tasks for supporting teachers learn to teach include students-focused classroom observation, cases construction, assessment tasks along with analyzing students' responses to the tasks, students-based curricular investigation, and interviewing students. The engagement of each learning task has been published in a book (Lin, 2001). The investigation and the effect of each task were not reported here. Instead, you will be given an overview on how teachers used assessment tasks along with students' responses to the tasks to develop their understanding of students' learning.

Assessment tasks along with analysis of students' responses to the tasks

The assessment practice in mathematics classroom was designed to assist teachers in implementing the spirit of assessment standards into classroom practice (MET, 1998). Its aim was to assist teachers to explore their understandings about how students develop their understanding of mathematics, and how this can be supported through the program. Teachers were encouraged to use students' journal as a tool of gathering students' thinking processes, learning strategies, and mathematical understanding. The reasons of assessment tasks referred to in the study as the prompts of students' journal included that 1) journal writing is likely to bring to light thoughts and understanding that typical classroom interactions or tests do not elucidate (Norwood & Carter, 1996); 2) we want to establish a better means of communication among students, parents, and teachers about the kind of mathematics learning taking place in classrooms; 3) we are looking for a better way to assess the entire learning process of each individual by writing about mathematics.

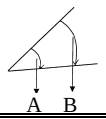
In generating mathematical tasks, the concerns include that: 1) supports a method of assessment that allows students to demonstrate their strengths rather than weaknesses; 2) stimulates students to make connections for mathematical ideas; 3) promotes problem formulation, communication about mathematics, justification of one's argumentation; 4) poses good tasks that do not separate mathematical thinking from mathematical concepts; 5) generates the assessment lesson-lesson tasks for inspecting what and how students learned from today's lesson. To generate the high quality of the tasks in a limited time and to answer high quality of tasks, the assessment tasks in each student's journal including one or two items were allowed. Thus, the tasks designed by the participant teachers and their analyses of students' responses to the tasks become as the major elements of the assessment portfolio.

The teachers had little knowledge of assessment integral to instruction, so that classroom observation was used as a means of

increasing teachers' awareness of generating assessment tasks in which were initiated from the lesson observed by the teachers. Routine weekly meeting provided the opportunities with sharing creative tasks each other and helping them to rethink how well the tasks for gathering information of students' in-depth understanding. The teachers observed one or two other teachers' teaching routinely on Monday morning every three weeks and had a meeting lasting for three hours immediately after the teaching. The lessons of all teachers participated in the study were scheduled to be observed in turn. The instructor was asked to reflect on her own teaching and the rest of the teachers were invited to articulate what they had observed.

At the very beginning of the study, I encouraged them to create at least a task each week integral to their teaching. They required bring their students' responses to the tasks for others to analyze in weekly meetings. The use of tasks was to promote students' understanding rather than just for the work, therefore the following questions were supplied to nudge teachers to rethink: What do you expect to learn about your students from this task? Are you satisfied with your students' performance on the task? Did you really gain what you want to gather from the task? Besides, each teacher needed to report in public in the meeting what they learned from the tasks and what information they gathered from students' responses to the tasks. Data for this study was gathered through classroom observation, assessment tasks, and teachers' analyses of students' responses to the tasks throughout the entire two years. The weekly meetings were audio-recorded and then were transcribed literally. Tasks and students' responses to the tasks were copied as major data collected in the study. Working together on each assessment task for teachers was designed to expand their knowledge. The assessment task enabled teachers to make immediately instructional remediation for next day lesson was conducted in Yo's lesson involving in the meaning of angle, as an example of the effect of assessment tasks on teachers' recognition of students' learning.

The task Yo-Yo generated was to examine students' understanding of the angle in which they engaged in the day before lesson.

<table>
<tr>
<td>Task: Chinese version
小平上課時，畫了一個旋轉角，並畫了二個旋轉方向的記號，他個轉的角度比較大，請您告訴他，並說明理由。
(Mei, 04/21/2001)
  </td>
<td colspan="2">Task: English version
Linda drew a rotated angle with A and B as directions. She cannot tell which angle is larger, as the Figure. Please help her to solve it with your explanation.
 
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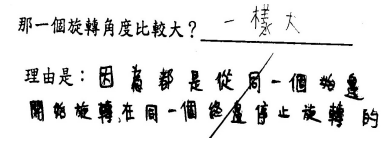
<td> 
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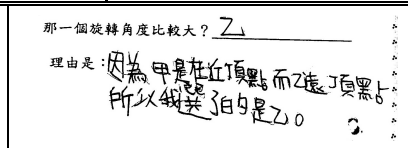
<td> 
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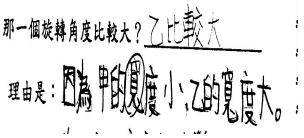
<td> 
</td>
</tr>
<tr>
<td>Student's response: English version
They have the same size. Because both angle A and B started at the same line and ended with the same line.</td>
<td>Student's response: English version
The angle B is larger than A, since the distance between the vertex to angle A is farther than to angle B.</td>
<td>Student's response: English version
The angle B is larger than A. Because the width of angle B is longer than A, so that B is larger than A.</td>
</tr>
</table>

Figure 1: Dai-Jing's Writing Figure 2: Wen's Writing Figure 3: Yi-Jer's Writing

After grading students' journal writings, the teacher, Yo-Yo, perceived that there were eight students with misconception of the meaning of an angle. According to the answers students responded to the task, the instructor understood that students misunderstood the size of angle either as the distance between the vertex to the mark at the angle, as shown Wen's explanation in Figure 2 or as the width between two sides of an angle, as Yi-Jer's writing in Figure 3. As a result, they identified the task with incorrect answer that angle B is larger than angle A. Relying on students' responses; Yo-Yo perceived that there is a need to help students correct their misconception with identifying an angle in next day lesson.

As playing in the VCD, at the very beginning of the next day lesson, the instructor asked Yi-Jer and Su-Ting came to the front of the classroom to explain their wrong answer. Yi-Jer said: "The width between two sides of the angle A was longer than that of the angle B". Soon after his explanation, the class made a noise, even in front of the observers. "How come?" "Impossible." were voices of what they shouted from their seats. The instructor followed: "Why did you disagree with Yi-Jer's thought?". At this time, many hands were waving and Dai-Jing was pointed by the teacher to explain for Yi-Jer. Dai-Jing said: "Both A and B started at the same line and ended at the same line." described as in Figure 1. Furthermore, Yo-Yo asked Dai-Jing to demonstrate what she means by "starting at the same line and ending at the same line". Dai-Jing exhibited an angle with moving a stick from a starting line to an ending line on the blackboard. The discussion among students interacting with the teacher is going.

The result indicates that the task dealing with students' misconception seems to be likely to enable teachers to make immediately remediation for the misconceptions. Thus, correcting students' misconceptions became a common work for the teachers at the very beginning of each lesson. Bedsides, the problem-posing tasks served to be an assessment tool and offering the information of students' cognitive levels (Lin, 2003). The task displaying various solutions that students resolved for a problem in the latest lesson helped teachers examine the individual understanding to one another's' methods. The classroom discourse on mathematical ideas became a major resource of conducting such kind of assessment task. As a result, this contributed the teachers to optimizing the quality of assessment and instruction, and thereby optimized the learning of the students.

The study suggests that designing tasks along with analyzing students' responses to the task was an effective way of enhancing teachers' knowledge of students' learning, because it provided the teachers with the opportunities to share insights of students' learning when they discussed students' responses to the tasks. The finding is consistent with the previous research on assessment integral to instruction (Chambers, 1993; Heuvel-Panhuizen, 1996). However, the assessment tasks integral to instruction referred to in the study were characterized by the tasks conducted by the researcher collaborating with same grade classroom teachers. Most of the tasks

for assessing students' learning referred to in previous studies are either designed by researchers only, or the assessment is merely a test at the end of instruction (kamii & Lewis, 1996). Comparing to assessment tasks developed by individual, sharing multiple perspectives of appreciating the value of each task in a school-based assessment team was more likely to enrich the purposes of task and broaden the varieties of task. Therefore, the tasks designed in the study provide more opportunities for students to clarify and extend their understanding and for teachers to gain knowledge of students' thought informing their instructional decision-making.

Learning contexts

(1) Collaboratively professional team

The research on teacher education was based on providing teachers with the opportunities for dialogue on critical pedagogical issues related to the mandated curriculum. The professionally collaborative team was set up to discuss the situations that occurred in a particular teacher's classroom and to compare them to others. Regular weekly meetings become as regular participation for the teachers in the program. The team creates an environment for teachers' learning in which, through professional dialogues, teachers could communicate what they were learning in their own classrooms to their colleagues.

The collaboratively professional team consists of the researcher and same grade teachers in a school. The researcher plays different roles to facilitate, probe, give feedback to teachers. The classroom teachers are expected to a practitioner of implementing curriculum into classroom. Regular weekly meetings of each year research are arranged for discussing the learning tasks and the concerns addressed from classroom observations. The result indicates that the professional team improves the quality of each learning task (Lin, 2001). The use of assessment tasks described previously was the evidence.

(2) Classrooms

In Taiwan, each teacher teaches a class for a two-yea cycle. Same grade classrooms were the primary contexts for these teachers to frame problems, analyze situations, and argue the advantages and disadvantages of various ways of teaching. There were two reasons for selecting teachers from the same grade to participate in the program. The first reason was that the teachers, teaching the same mathematics topics, confronted similar pedagogical problems. Similar mathematical content lent itself readily as a focal point when the teachers met together after observing each other's lessons to address issues and solve pedagogical problems. Secondly, similar pedagogical issues addressed in the regular meetings drew attention and concern from each teacher, leading to in-depth discussions. The first- to third- grade classrooms are the primary setting corresponding to the first to the third year of the program. The result indicates that such same grade teachers' involvements

make them examine classroom discourse or analyze students' work deeply. The more effects of classroom observation on teachers' pedagogical content knowledge have been described in Lin's book (Lin, 2001).

Dimensions of Teachers' Professional Development

The teacher professional program reported in the paper shows us the dimensions of teachers' professional development. What it means by teachers enhancing their professional development is that teachers increased three-domain knowledge, grew their self-awareness, changing school cultures, transferring and disseminating research result into other mathematics communities.

The result shows that teachers improved their self-awareness referring to make sense of mathematics teaching and gain their conceptions of learning. The change of teachers' beliefs and knowledge was inspired by the learning tasks. Beliefs are assumed to be amenable to change over time as a result of some processes, although the process of change is often not specified. The processes referred to in the teacher professional program including learning tasks and social learning contexts make teachers change on their beliefs of teaching and learning mathematics, and then develop their three domains knowledge and their reflection on practices.

This research suggests that the investigation of research on school-based teachers' professional development can not be isolated from school context. The teachers involved in the research were interacted closely with their same-grade and other colleagues, administrators, and parents of the school students. The teachers had the opportunity to bring the new ideas of teaching and learning to their colleagues, and then make the school cultures change. Besides, teachers are able to transfer and generalize their knowledge and ability into other learning communities.

Suggestions for Research on Primary Teachers Education Program

I would make suggestions on the methodology of the research on teacher professional development program. First, the process of learning to teach for teachers should be taken as a whole instead of away from social contexts. Second, teachers learning to teach cannot be achieved alone, rather, collaboratively with their colleagues. (3) Teachers' learning to teach successfully occurred in a realistic classroom practices. (4) Theoretical reflection becomes a process of teachers learning to teach.

The first two components refer to the close relationship between teachers' professional development and school organizational development. The learning theory for teachers I proposed underlines the importance of school organizational development. To help teachers implementing the curriculum reforms into classroom, it is necessary to change the contexts where teachers act. To make this success, teacher education program becomes a permanent process, integrated in the teaching life of teachers and school. In terms of

authentic contexts of learning, classroom is a natural setting of teachers' learning to teach. On the basis of observation, the result indicates that it is impossible to enhance teachers' knowledge of students' learning unless the professional program provides the illustration of students' mathematics learning by analyzing teaching practices as it occurs in the classroom. The classroom observations provide the teachers to see what and how teachers interacted with students in the classroom without intimidating the students or imagining what the situation looks like and without removing the complications of a live teaching. Finally, the theoretical reflection as a process of learning to teach demonstrates how the theory helps teachers understand the practice. However, if the reflection without theory supports, it could not function in enhancing teachers' professional development. The reflection is oriented by the theoretical framework of the research. Therefore, the meaning of theoretical reflection is beyond either reflection or theory alone, reflection either as a catalyst or as a precondition for the process of constructing meaning and knowledge, such as learning from one's own observations and analysis.

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