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Challenges and Dilemmas in a Period of Reform --- Preservice Mathematics Teacher Education In Shanghai, China

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Abstract

Teacher education in the world suffers from some longstanding dilemmas. In this article, three major dilemmas, balance of disciplinary and pedagogical training, relation of theory to practice and role of teacher education as reproductive or as change agent are examined in a culture that has a long history of powerful traditions yet is in the midst of tremendous social and economic transformation. The story of preservice teacher education in a moment of transition and its effort to resolve recurrent dilemmas with new meanings vividly presents itself in the reform process of the mathematics departments of the two teacher education institutions of Shanghai.

Introduction

There are some long-standing dilemmas that perplex teacher education around the world, such as the balance of disciplinary and pedagogical training, the relation of theory to practice and the role of teacher education as reproductive or as change agent. This paper is an effort to examine these dilemmas in a culture that has a long history of powerful traditions yet is in the midst of tremendous social and economic transformation. This is a story of preservice teacher education in a moment of transition and its effort to resolve recurrent dilemmas with new meanings. We focus on the reform process of the mathematics departments of the two teacher education institutions of Shanghai.

We develop our ideas around three major concepts: challenges, dilemmas and change. A society in transition shows "disturbances of habits" (W. I. Thomas,

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1909, quoted by Elder, Modell & Parke, 1993, p.4). Hard-to-resolve disturbances relapse into dilemmas, which are defined in this paper as classical problems that are generic and persistent in nature. As Lampert (1985) reminds us, dilemmas are hard to solve, if not impossible, and it is more a case of managing dilemmas than solving them. Challenges posed by transition can also cause or exacerbate dilemmas. In our examination of Shanghai's preservice mathematics reforms, we note changes, but they appear as a kind of piecemeal tinkering that represents cyclical efforts at change (Tyack & Cuban, 1995; Kingdon, 1995). These efforts at the same time appear to be satisfying and solution driven (March, 1981).

This paper begins with a delineation of some of the major challenges faced by teacher education in general and the work of preparing mathematics teachers in particular in an age of transition. Here challenges are seen as pressures for reform exerted by national economic reconstruction and local economic and social developments, political and institutional restructuring mandated from the top down, and school reform that occurs from the bottom up. This section serves as contextual background for understanding the dilemmas to be discussed in the second section. The second section, which is the major part of the paper, examines three dilemmas that beset mathematics teacher education in Shanghai. In a brief third section, we reflect on the nature of changes observed in teacher education.

The data in the paper come from a NSF-funded study, "Middle Grades Mathematics and Science Teachers Induction in Selected Countries" in which Shanghai is one of four case study sites, including a second mathematics case (France) and two science cases (Switzerland and New Zealand). Our data represent ongoing fieldwork, including interviews, observations and official policy and school-level documents.[1]

[1] This paper thus represents work in progress. Data collection has not been completed, although two intensive fieldwork trips have been completed during 1999. This paper draws on work completed in 1999 and at the time of this writing , was not able to incorporate the recent round of data collection fieldwork of 2000. Prior related work done in Shanghai (and in China more generally) by both Paine and Fang also contributes to our understanding of these issues. Fieldwork for the project in 1999 involved interviews and observations at teacher education institutions, schools, and professional development sites, as well as interviews with Shanghai central, district and school administrators and researchers.

I. Challenges: Understanding the Context

A. Systems in change: social, economic and educational transition in Shanghai

Shanghai, located at the west coast of the Pacific where the Changjiang, the largest river of China, joins the East Sea, is the largest port and industrial city of China and one of the largest financial centers in Asia. With a population approaching 14 million, anything Shanghai does with energy is ambitious in scope. Today, Shanghai is in the midst of dramatic social change and aggressive reforms of its economy and education. These create challenges and new expectations for those responsible for the preparation of beginning mathematics teachers.

In the current reform, Shanghai is called the "head of the dragon" *(long tou)* leading China's economy. Although one of China's earliest industrial bases, for decades under the planned economy Shanghai provided a major source of national revenue and did not reap the fruits of its growth. Major investments were not made in Shanghai's infrastructure until 1993, when Deng Xiaoping made a landmark speech calling for Shanghai to make a big difference in three years. Miracles happened. In just three years, the city transformed its appearance: skyscrapers, large shopping centers, office buildings rose one after another in downtown area and clusters of residential complexes on the outskirts of the city. Subway lines and overhead roads were built and businesses started. Nanpu Bridge appeared above the Hungpu River connecting the western part of Shanghai (*PuXi)* with its undeveloped eastern land *(Pudong)*, which is now the largest "Tariff-free Zone" and the new financial center. Significant for our study, Pudong also represents the district with the largest number of beginning teachers and numerous new schools.

Most of the construction projects have been built with foreign investments that also constitute the major financial source for the industrial and economic reform. Joint ventures and township enterprises are moneymaking, while the big and overburdened state enterprises, no longer fit for the new roles of the market economy, have become money losing. These industries have laid off a large number of their workers. Dreaming of becoming rich overnight in the new and not-yet-standardized stock market, the laid-off workers invest their time and money in the stock market. The disturbances incurred by the transitional economy cause potential social instability. It is now the government's biggest agenda to bring the many laid off workers back into the economy. The big wave of social change and market effect inevitably impact the education system and families as well. Education has long been seen as needing to serve the purposes of economic development. Hence, educational content and goals have to be adjusted to adapt to and serve economic construction.

Along the way, the city is experiencing rapid urbanization of its rural counties and schools are relocated. For a long period of time, the city proper of Shanghai had 10 districts, but as rural counties are urbanized and become administrative districts, that number increased to 15 by 1998. Demographic changes in Shanghai have had educational implications. Thus, for example, the urbanization and institutional reorganization gave rise to relocation of schools. With the town center turning into financial business centers, the real estate there has skyrocketed. Schools located in the center of the city have sold their land and moved to the suburbs to build new and better ones. In 1998, municipal government started building 10 key senior high boarding schools (all used to be downtown). These schools are to be the cream of the crop, with exceptional physical plants (for example, with indoor swimming pools and big modern gyms) and consistently outstanding academic achievement.

Together with the further implementation of nine-year compulsory education, institutional reorganization includes the grassroots level. Starting from 1999, junior and senior secondary schools that were merged not more than 10 years ago to form a single secondary school are being separated again. To make the separation a smooth transition has become one of the projects in the agenda of the Shanghai Municipal Government (Wang, 1998). What impact the split of secondary schools will create on school culture and teaching and learning is worthy of attention.

Table 1 below provides information about the size of the system in terms of student enrolment and teachers in 1997. Although the statistical figures have not changed remarkably, the locations where they belonged have since changed dramatically. In 1997, enrollment in junior secondary schools (not including vocational technical schools) was more than three times the size of senior secondary schools' population.

Table 1. Number of Students and Teachers of Shanghai by Level, 1997

	Schools	Enrollment	No. of stuff and workers	
			Total	of which: full-time teachers
Secondary Schools	812	744,800	74,900	48,700
--Senior High	Not available	175,500		10,800
--Junior High	Not available	569,300		37,900
Vo-tech Sec. Schools	75	102,852	6,955	3,981
Elementary	1533	1,024,400	69,200	52,400

Source: *Shanghai Education Yearbook, 1997*, Shanghai Education Commission, Shanghai Education Press (1998)

Note: Vocational technical schools are not included in regular secondary schools in Shanghai.

The mid-'90s was a time when the baby boom generation went to junior secondary schools. More senior secondary schools have had to be built in recent years to accommodate the sudden increase of enrolment in senior secondary schools. All this happened at the same time that junior and senior secondary schools have been separated into independent campuses. The increased student population has implications for the teaching force. As indicated in Table 2 below, more than 60 percent of junior secondary school teachers have completed 3-year colleges (receiving a degree lower than a BA). Yet this represents a problem now that the official level required of junior high teachers to be considered qualified is completion of a 4-year undergraduate (BA) degree program. Thus, a majority of junior high teachers have to receive education on the job to meet the new qualification requirement.

Table 2. Secondary Teachers of Shanghai by Qualifications, 1997 (%)

	No. of Teachers	4-year College-degree & above	3-year College	Sec. Teacher Training Schools	Senior High School & Lower
Senior High:	10,804	81.35	17.89	.34	.42
--City proper	8,800	82.15	17.17	.33	.35
--Counties	2,004	77.84	21.06	.40	.70
Junior high:	37,856	32.25	60.17	3.30	4.55
--City proper	30,444	35.46	58.16	2.68	3.70
--Counties	7,421	19.06	68.43	4.45	8.06
Vo-tech Sec. Schools	3,981	50.94	44.33	3.19	3.54

Source: Same as Table 1.

B. *Restructuring of teacher education*

Shanghai finds its education needing to change to meet shifting economic and social conditions, demographic changes, and new expectations for schools and teachers. So too has teacher education been undergoing reform. Today Shanghai's teacher education's developments reflect broad reforms in higher education nationally as well as more targeted restructuring of the provision of teacher education in the city.

Traditionally teacher education in Shanghai involved a large mix of different types and levels of institutions with separate and overlapping missions. Some concentrated almost exclusively on preservice, some on inservice and some worked in both realms. Similarly, secondary normal schools, two and three year teacher education colleges, and four-year colleges and universities all were players in Shanghai's teacher development work. These institutions brought quite varied institutional cultures, and they were administered and funded by separate divisions of the government (some, for example, administered by the municipal government, while an institution such as East China Normal was a "national" university whose resources and regulations came from China's central ministry of education).

In 1998, the institutional reorganization, which had been contemplated for quite a number of years, finally took place. Starting from the Central government, it soon swept to every sector and down to grassroots-level local schools. March (1983) points out that "the comprehensive administrative reorganization has been persistently resurrected by the political system," and "the systems of meaning" of reorganization in political and organizational life is "gradually evolving" (p.281). For China, too, restructuring reflected a long-term plan. The impact of the reorganization needs to be evaluated in the long run. In the short run, however, the chain effect resulted from the big action throughout the national machinery without discrimination (in a clear-cut manner) would inevitably cause "unlamented casualties of experience" (p.281).

In the administrative reorganization movement, many central agencies disappeared because of mergers. The overstaffed and massive Central government ministerial organizations were reduced to 40 ministries and became highly streamlined. The State Education Commission was renamed the Ministry of Education. One of the most important consequences has been to shift the balance of funding for national key universities. This process partially weaned the financially dependent key universities from their ministerial sponsors. This forced them to seek local budgetary resources. For the case of Shanghai, one of the most affected institutions of higher education is East China Normal University (ECNU), one of the key national universities in China. In the last four years, in order to get budgetary support from the Shanghai Municipal Government, it has lowered its sense of exclusiveness and taken initiative to increasingly involve itself with the education and teacher training responsibilities of local schools of Shanghai.

In addition to this sweeping chain effect of administrative reorganization with pressures coming down from above, institutional reorganization also happens in response to pressures coming from the needs of the society and time. There had been a systemic teacher training network in Shanghai before 1997 with six prestigious institutions of all levels sharing the training responsibilities (similar to those that are still existing in other parts of China). Preschool and kindergarten teachers were trained by specialized Secondary Preschool Teacher Training Schools; elementary teachers trained in Secondary Teacher Training Schools; junior secondary teachers in 3-year Teacher Training Colleges or 3-year programs in Teacher Training Universities (in this case, mainly Shanghai Teachers University (STU) which for many years has been the major or only teachers university catering to Shanghai's junior and senior secondary schools). ECNU, the key normal university for East China, produced backbone teachers (what might be seen as teacher leaders) for provinces in the eastern region of China as well as senior secondary teachers for Shanghai. Some of its graduates traditionally have gone into higher education teaching and research. Except for some educational courses, the curriculum in mathematics and other departments at ECNU was traditionally said to be no different than that of comprehensive universities.

Starting from the mid-1990s, a surplus of preschool and elementary teachers began to occur. The Municipal Education Plan for the 9th Five-year Plan period (1996-2000) moved the academic qualification requirement to a higher level: Elementary teachers should complete 3-year college education, junior secondary teachers 4-year undergraduate training and senior secondary teachers at least 4-year undergraduate training or complete a postgraduate program.

To support these new standards, the city's six major teacher training institutions were merged into either STU or ECNU and the two universities became the major teacher training institutions in Shanghai since 1998. They each share distinctive training responsibilities: STU trains elementary and junior secondary teachers and ECNU trains senior secondary teachers. They also are providing teachers professional development, which in China, people prefer to call teacher in-service continuing education. Teacher continuing education has now become the major training task for higher learning institutions, district education institutes and local schools themselves in the 9th Five-year Plan period.

In the last four years of the 1990s, local school principals enjoyed more decision-making power in the Principal-responsibility System. Out of their strong desire to improve teacher quality of their schools many began to hire graduates from universities other than teacher training programs and place them in teaching positions after some on the job training in educational courses. This was also a time when the knowledge and skills of beginning teachers trained at the so-called "closed" system of both universities came under criticism. The recent introduction of the market mechanism in the labor market promotes job mobility and competition and also a new sense of job insecurity. As a result teaching, with its relative security, has become a more desirable job for many university graduates.

These various changes led to a shift in the demography of the new teaching force inducted into Shanghai's local schools. Previously, prospective secondary teachers were mainly Shanghai young people trained in the two teachers universities (Policy forbade non-residents of Shanghai to become civil servants of Shanghai before 1995). Now they come from multiple sources: graduates of comprehensive universities and those introduced from out of Shanghai. In 1996, for example, the number of teachers coming from other provinces to teach in Shanghai (including both beginning and experienced teachers) was 1,230 and the number of graduates from Shanghai's comprehensive universities were 273. The two sources adding together were 1,503, almost equal to the number of graduates from STU and ECNU, 1,635 who entered teaching that year. (Wang, 1998).

With comprehensive universities entering into the labor market, ECNU and STU are very concerned about their position. In fact, the sense of challenge and crisis has pushed the two universities to take actions for survival. Both of them years before had established non-teaching programs whose graduates are usually in high demand; these include programs such as computer science, electronic engineering and marketing. At present, almost 50% of the enrollment of STU and 60% of ECNU are in non-teaching programs (Wang, 1998). Training of school teachers in Shanghai is no longer the major responsibility of teacher training universities; it is shared with different comprehensive universities. What will become of ECNU and STU? Many researchers in Shanghai believe that Shanghai will lead the country to establish colleges/schools of education in comprehensive universities like Fudan University. When such a time comes, will the dilemma that teacher training in Shanghai offers insufficient pedagogical training and is discipline-based become reversed, like in the case of US?

C. *Dynamic school reform producing new challenges*

Challenges for preservice teacher education in Shanghai not only are coming from top-down but from bottom-up as well. The dynamic school innovations often push the reluctant and slow-changing normal universities to change. Shanghai has led China as a hotbed of school reform.

One of the most notable aspects of Shanghai's education reform is its creation of its independent curriculum, one distinct from the traditional national curriculum. We discuss later in this paper the curriculum's implications for mathematics teacher education. But another feature of Shanghai's reform is not mathematics-specific. Here we refer to what typically gets translated as "quality education."[2]

One assumption underlying the recent curriculum reform is that one ultimate goal of education is to promote and develop individual growth, potential and personality. The traditional unified curriculum and text-centered instruction have been harshly criticized for neglecting diverse student needs and aptitudes.

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[2] The translation of suzhi jiaoyu as quality education is, for us, problematic, since we do not feel the English term carries any clear meaning. But since this Chinese term has got a standard English translation, we use it reluctantly for now but urge the reader to attend to the description given of it, rather than the term itself.

Humanistic educators and educational researchers have been wary of official statements such as "education should serve proletarian politics," or "education should serve economic construction." They have claimed that education should, first of all, serve the developmental needs of each human being, while taking the social context into consideration.

Although the humanistic view is never dominant, it has been integrated, to some extent, into the reform rhetoric. Thus, in addition to the traditional missions to instill patriotism, cultivate collectivism, and foster a sense of social responsibility among the students, it was also stated in the *Curriculum Guides for Primary and Secondary Schools in Shanghai* that schools need to "ensure the rudimentary formation of students' individual personalities and nurture their individual strengths," and that students "must have will and determination, as well as the ability to adapt to change; they must have the spirit of exploration and creativity".[3] Such goals used to be absent in official educational documents. These new requirements present a considerable challenge to educators who have little experience in identifying, developing, and assessing students' individual strengths, adaptability, creativity, and the like.

In practice, the humanists advocate that students should be active explorers rather than passive receivers of knowledge. Thus, learners should play a central role in all educational activities, which used to be dominated by either teachers or textbooks. Along with this view often comes constructivist concepts of knowledge: that knowledge should not be treated as fixed, isolated facts but constructions of human minds that need to be reflected upon, criticized, and further developed. These new concepts are appealing to those practitioners who are dissatisfied with the conventional text- and test-driven curriculum and instruction, although it is always hard to transcend the vast gap between theory and practice, tradition and vision.

Today the term "quality education" (*suzhi jiaoyu*) comes to serve as a sort of catchall for these sentiments of reform. Defined most commonly in terms of its contrast with promotion-driven education, quality education has as two of its chief tenets the goal of educating all children (not just those heading on to further education) and educating the whole person (not just their cognitive abilities that are needed for university admission). While the term quality education littered our interviews, often in some introductory description about the challenge facing teacher education, a district or a school, we found wide-ranging responses to our probes about its meaning. Most common were statements about this being a time

[3] Chinese Education & Society, 1994, No.3, 43-46.

of "groping" towards some understanding of what it is, at the same time it is being implemented. That there is such a visible reform in the air, but one that still is relatively unclear in terms of its playing out in individual teachers' practice, seems like one more important part of the context that makes up new teachers coming to learn to be successful mathematics teachers. In understanding the kind of practice new teachers are expected to develop and which teacher education is intended to support, it becomes both a goal and—because of its uncertainty—a challenge.

In Shanghai, in addition to Shanghai-wide reforms (such as curricular developments and the emphasis on quality education), local schools are brewers of many reform innovations. For instance, under the support of Zhang Mingsheng, the city education authorities established five school-based research institutes. Each focuses on a different reform, developed at the grassroots. They are very different in a sense that research done there includes the teachers as professional researchers. The biggest difference is that these reform projects were originated at the school level. That there are five such centers/institutes suggests the complex and multiple versions of reform at play in Shanghai today. Taking this into account, it is fair to say that in many respects, the practice of teaching itself is evolving, and not remaining static.

Given this dynamic set of forces influencing education, as well as the internal dynamic of education reform in Shanghai, what does this mean for preservice teacher education? The institutions engaged in such work are themselves in a period of transition, and the practice they are to help their students construct is under revision. What does this mean for how teacher education proceeds? As we examine current practices and policies in the two leading teacher education programs for secondary mathematics teachers in Shanghai today, we note this challenging context. The situation of these programs is one that seems to highlight longstanding dilemmas and add new complications to their management.

II. Dilemmas

A. *Understanding of Mathematics and Mathematics Education*

What constitutes an adequate preservice mathematics training program has long been debated in many countries, especially in terms of the balance between a sufficient proportion of mathematics disciplinary knowledge and pedagogical knowledge (e.g. Dewey, *Relation of Theory to Practice in Education*, 1904). No less controversy has been going on for a long time about what should be included in pedagogical education. In China, the teacher training system traditionally relies on normal universities and teacher training colleges and schools to educate teachers. Normal universities, particularly the key ones directly administered and funded by central education authorities, have been blamed for their strong emphasis on academic disciplinary training and their giving very limited attention to pedagogical training. This arrangement also reflects the long-standing belief that teachers cannot be prepared by university programs alone; graduates become teachers and learn to teach only after they enter teaching positions at schools and learn by doing on the job. Completing teacher training programs, new teachers are regarded as "semi-finished products" *(ban cheng ping)*.

Therefore, mathematics teacher education in China can be said to be discipline-based with a very small amount of mathematics education courses and limited exposure to student practice teaching. Things are changing, however, in the understanding of mathematics and mathematics education in teacher education programs in Shanghai as a result of recent school education reform that calls attention to the need to train children's creativity and make the content of learning connected to students' lives.

Discipline-based

Traditionally, the emphasis of preservice education is placed on mathematics disciplinary knowledge. As noted by a teacher education researcher at ECNU, the Chinese model of teacher education is one similar to training disciplinary specialists and medical doctors, with the proportion of professional courses being very limited. Until most recent years, education courses have been made up of the so-called Three Big Courses (*Da San Men):* Pedagogy, Education Psychology and Mathematics Teaching Materials and Methods (a subject-related pedagogy course provided in the specialization department). Education psychology and Pedagogy have been offered by the General Education Teaching Research Section of a normal university that is responsible for offering the general education courses for students of all majors. Such courses included, for example, Political Economics, History of CPPC, Marxism and Leninism, foreign language, physical education and others, to name a few of them (see Table 3 for details)[4]. Because of the long-standing stress of disciplinary training and neglect of education courses, ECNU has recently established a Teacher Skills Training Center to fill the gap.

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[4] The first two of these courses were dropped from the curriculum in 1999, which to many, stands out as a remarkable revolution that "could enter historical record in the process of democracy" (Interview, May, 1999). This big curricular/political decision indicates the country's shift from political economy to market economy.

Embedded in this long tradition lies the fundamental belief that discipline-based knowledge is the cornerstone of good teaching. The authority of mathematics teachers is deeply rooted in how much they know about and are able to solve mathematics problems. In our interviews with two noted Shanghai mathematics educators, we were told that it is still very important for a secondary mathematics teacher to be able to solve different problems, but these educators made a conscious distinction between solving problems and problem solving. Student teachers we observed and interviewed also felt that the inability to solve a problem posed by their students became real challenges to their authority as a teacher. The gap between solving problems and problem solving is created by treating mathematics as procedures and rules which are formal, deductive and symbolic in the form of textual knowledge and treating teachers as specialists whose role is to impart this knowledge to passive students. Systematic fundamental mathematics knowledge is taught and consolidated through diligent and large quantity of drilling and solving problems based on rules and axioms across classrooms of elementary, secondary and higher learning institutions.

Current reform of school mathematics

Like many other countries in the world, China is also concerned with training children's creativity and strengthening relevance of school knowledge to real life. In the 1999 Annual Education Working Conference, President Jiang Zeming set creativity training for children as a major agenda. He stressed that this is decisive for the fate of Chinese people in the next century. Mathematics is widely held in China as high-level knowledge that trains students' abstract, logical and systematic way of thinking. Yet the way of teaching and learning it is most often teacher-dominated passive reception of procedures and rules followed by large quantity of drills and solving problems on textual knowledge.

It is important to understand the historical roots of mathematics in Chinese education. Mathematics is a relative newcomer to Chinese education, for it appeared only at the end of the 19th century after a string of humiliating defeats for China at the hands of the West. To make China rich and strong, reformers argued, mathematics would bring salvation to China. Before this, in fact, distinct "subjects" were not part of the Chinese view of education. But concerns for competing with the West gave "subjects" a relevance: Mathematics, for example, would allow the Chinese to develop their knowledge of chemistry, physics, mechanics, cultural and intellectual capital perceived by the Chinese as the real threat of the West. At the same time, it became common wisdom that mathematics "trains thinking." One might forget the specific mathematics learned in school, for example, but the methods of thinking help one throughout life. Mathematics quickly rose to the top of education, and became central in the examination system, a system that determines what an old saying refers to as "whether one wears straw or leather shoes."

Shanghai is now undertaking its second major cycle of reform, with the first cycle beginning in 1988. (The second cycle appears still to be in an early stage and not yet implemented citywide.) The initial push for reform (what became the first cycle) was motivated by a desire for a big change from traditional mathematics teaching, moving away from focusing on lots of content and emphasizing instead helping students to study/learn mathematics well. By 1991 schools began to use the new materials. The new curriculum structure in mathematics for junior high includes both required and elective courses and some mathematics-focused extracurricular activities. Electives represent a small part of the whole. This first cycle is a big change from what preceded it, but "it is still not perfect", according to the curriculum researchers interviewed, especially in the links between the curriculum and real life. The second cycle, among other things, hopes to address some of these problems.

For junior high, there is an effort to strengthen the "basic quality" of algebra and the logic of geometry. Across K-12, there is a goal of strengthening the links to real life and strengthening the "practical aspects" of mathematics education. *(Guideline for Mathematics Education in Primary and Secondary Schools for 21st Century, 1999).*

One curriculum reformer explained: "Now the curriculum is divided into three stages. In the first two stages the emphasis is on observation and experimentation that require generalization and induction, not on rigorous proof. Logical proof is introduced in the last stage. Of course, the requirement for students' logical-proof ability is lower than before. In the past we cut off the originated resources and the practical applications of mathematics knowledge. Mathematics became formulas and theorems. We didn't care where it is from, where it will be applied or how useful it is." (Interview, 5/99).

This last comment echoes a theme we heard repeatedly in interviews with mathematics educators and curriculum reformers. In our interviews, the most commonly heard reform rhetoric of school mathematics is embodied in metaphor of "a fish cooked without head and tail" *(shao zhong duan).* It hits the nail on the head of the problem in mathematics curriculum and teaching: a complete mathematics process goes through three phases --abstraction, sign unpacking and application; teaching and learning the middle phase alone separates mathematics education from reality and mathematics knowledge becomes "cut and dried" and fragmented. A mathematics educator at ECNU told us that they had been debating about what constitutes the essence of mathematics and what really needs to be taught to students. She thought that in the past, people felt like if you give the students the structure and system of mathematics knowledge, they could do application. Application could not come before students have had that abstract system of thinking. When talking about application, the mathematics educators we interviewed at ECNU discussed it in relation to basics. They argued that it was the concern of mathematics and mathematics education circles not to emphasize one and ignore the other: let students master application and still do not let them lose basics.

The current new reform effort seeks to restore the "head and tail" of mathematics knowledge by introducing in the curriculum where mathematics comes from and to where it goes in the service of human life. This represents new understanding of mathematics which views mathematics not only as a knowledge that trains abstract, logical and systematic reasoning but also nurtures creativity. It represents mathematics as knowledge not only useful for school academic learning, but for application to real life. In the mean time, the main trunk of a systematic fundamental mathematics knowledge, which is the essence of traditional Chinese mathematics curriculum, is to be kept but streamlined. *(Guideline for Mathematics Education in Primary and Secondary Schools for 21st Century, 1999)* The whole fish should be presented to learners. It seems that mathematics and mathematics education is endeavoring to seek a balance between nurturing creativity, building relevance of mathematics to life while keeping the basics. This also refers to what is often heard in the education circle, "tradition plus reform".

To embark on this ambitious task, the teacher education institutions have to take on the responsibility of preparing prospective teachers in both knowledge and skills necessary for carrying on the reform at schools they are going to teach.

Response of mathematics preservice training to school mathematics reform

In China, the reform steps of elementary and secondary education are faster than those of teacher training institutions. It is often the case that teacher education curriculum is forced to change under the pressure of the changing needs of basic education. This is not easily perceived when universities are very loosely connected with local schools they serve. The strong current of reform and the force of an increasingly open market for university graduates to become school teachers have pushed the exclusive teacher training programs to decide either to change for survival or be driven out of the market. We could feel such a tension at the two normal universities and we saw their efforts to adapt to change in the new mathematics curricula of both ECNU and STU. On the other hand, the new structure and content of the syllabus played out differently for both institutions in both the provision of courses and the approach to student teaching. Each, by taking advantage of their areas of strength, makes adaptations for change and survival in the increasingly open labor market of teaching employment. The advancement of technology, however, pushes both institutions to train their students' application of computer-aided mathematics education.

East China Normal University

In line with the requirement of Ministry of Education, both normal universities have worked out their new syllabi in 1999 (Refer to Table 3-4). The structure and content of these represent their vision of reform and new understanding of mathematics and mathematics education. In view of the emphasis on building strong mathematics foundations, an inherited strength of Chinese mathematics teaching and learning, ECNU has kept the teaching hours of foundation mathematics courses unchanged, but consolidated with adjustment the offerings that strengthen the application of mathematics courses. Examples include Mathematics Modeling, Differential Equations and Computation Methods, Mathematics Experiment and Use of Mathematics Education Software and others in the new required courses for both teaching-track and non-teaching track students (See Table 3 below). For students who are would-be teachers, their required and elective courses are also more applied in nature, such as Linear/Nonlinear programming, Statistics and Probability, Environment & Mathematics Modeling and so on.

Table 3. East China Normal University Curriculum of Mathematics Education Program

Course	**Credit**
	Total : 156
Commonly required	**38**
Common electives	**6**
General courses (College-wide)	**11**
C Language	3
General physics	6
Electronic technology	2
Required courses in specialized field	**77**
Mathematical experiment	1
Analytic geometry & algebra	12

Table 3 (...cont'd)

Course	**Credit**
Calculus	6
Multiple calculus	6
Advanced analysis	6
Teacher's oral language	1
Ordinary differential analysis A	2.5
Abstract algebra A	2.5
Mathematical modeling	3.5
Probability and statistics	4
Complex analysis	2.5
Differential geometry A	2.5
Psychology	2
Computation methods	3.5
Real analysis	3
Pedagogy	3
Mathematics teaching methods	2
Lectures on modern mathematics	1
Mathematics education activities	1
Teaching practice	6
Graduation thesis	6
Elective courses	**24**
Limited selection (8-10 credits required)	***(8-10)***
First group	
Advanced algebra study	2
Ordinary differential analysis B	2
Abstract algebra B	2
Mathematical equation	2.5
Differential geometry B	2
Functional analysis	2.5
Topology	2.5
Second group	
Classical geometry	2
Fundamental number theory	2.5
Linear programming	2.5
Evaluation and testing	2

Table 3 (…cont'd)

Course	Credit
Introduction to math edu.	2
Mathematics edu. Software	2.5
Elementary math research	2
Unlimited elective courses (13 credits required)	***30 (13)***
Teacher education	
Modern math and Secondary school math	2
Mathematics curriculum	2
Philosophy and history of mathematics	2
Solving problems and math competition	2
Mathematical methodology	2
Foundational mathematics	
Fluid calculus	2
Carowa theory	2
Module and group representation	2
Lee algebra	2
Algebraic curve	2
Typical group	2
Applied functional analysis	2
Complex analysis continued	2
Applied mathematics	
Statistical methods	2.5
Biological mathematics	2
Environmental mathematics modeling	2
Applied mathematical methods	2
Introduction to ramose theory	2
Applied differential analysis	2
Operational control	
Combinatorics	2
Graph theory	2
Modern Cybernetics	2
Computer serial	
Matlab language	2
Unix operational system	2

Table 3 (…cont'd)

Course	**Credit**
Applied mathematical software	2
Data bank	2
Economics-related mathematics	
Mathematical theory in investment	2
Mathematical methods in financial investment	2
Microeconomics2	2
Mathematical modeling in economics	2
Econometrics	2
English for specialization	2

Source: Teaching Syllabus of Mathematics Department of East China Normal University for Mathematics and Applied Mathematics Majors, September 1999.

As shown in Table 3, in the area of mathematics education, besides Mathematics Pedagogy, there is one course, Mathematics Education Activity, designed to match up to the secondary school "Activity" classes (one piece of the three-piece second cycle school mathematics curriculum reform, the other two being Required and Elective classes). In the pool of electives, mathematics education courses such as On Mathematics Curriculum, Foundations of Solving Problems and Mathematics Competition, are provided to prepare teachers for organizing mathematics activity classes in secondary schools. This becomes clear when an administrator of Mathematics Department told us that since the secondary school curriculum was structured in three chunks, including the elective and activity classes their course provision followed this structure by broadening the scope of elective courses and giving consideration to activity classes at the same time.

Two other newly offered mathematics education courses are Introduction to Mathematics Education and Mathematics Teaching Assessment and Testing. The first, together with Mathematics Pedagogy, is designed to replace the old Mathematics Teaching Material and Methods, which was described as outdated in the sense that "it is only about what to teach and how to teach it" (Interview, ECNU, 10-99) and that it treated mathematics education as fragmented procedures and rules. The second, Mathematics Assessment and Testing, is a course not only targeted at theories of assessment, but also the relation of testing practice to understanding of teaching.

One class we observed found students working on a task that required them to analyze three years of university entrance examinations and then design questions around the analysis. They sorted the tested mathematics topics by topics and presented them in arrays on a chart by taxonomic levels of knowledge and assessment. They then looked at how the exams changed over time on key dimensions (e.g. amount of attention to creativity). Based on the analytical results, students offered 6 problems and put them on the blackboard. Then they discussed about them and worked on them. It appeared that the students treated mathematics as a technical activity, and in the course of that particular lesson they seemed more interested in mathematics than the education and pedagogical implications of the task.

Our follow-up interview with the course instructor revealed a complicated dilemma. The goal of the class aimed at teaching would-be teachers how to design tests that could both help them understand their students and reflect on their own teaching. Since the students had no teaching experience and were brought up to solve with text-based mathematics problems, they took it for granted that the content was easy for them and thus for their students in the future. The complication draws our attention to the classic problem of how to balance mathematics and mathematics education and what and how to teach in the education classes both theory and practice to future teachers who have no teaching experience as yet. The long "apprenticeship of observation" (Lortie, 1975) prior to university simply constitutes another obstacle for teacher educators who work hard to instill reform ideas in teacher education programs.

Shanghai Teachers University

STU used to train both senior and junior secondary teachers. It has become mainly responsible for training junior secondary and elementary teachers after institutional reorganization both because the requirement of teacher's academic qualifications is higher and also as a result of ECNU's willingness to take over more teacher training roles. Their required mathematics courses besides the foundational ones not only include the applied courses offered at ECNU but also those closely connected to secondary school mathematics as well (See Table 4 for details). For instance, mathematics analysis I, II and III (required courses), which are not provided at ECNU, lay emphasis on the thinking embodied in mathematics. One of the key mathematics educators at STU made special mention of this course. He said that although Mathematics analysis was also taught at key comprehensive universities like Fudan and Jiaoda (Jiaotong University) and the textbooks they used were not very different, while the other two universities aimed to train research and application ability, while STU'S vision helped students see the thinking and methods of mathematics.

Table 4. Shanghai Teachers University Curriculum of Mathematics Education Program

Course	Credit
Required courses	**Total : 189**
Marxism and Leninism	8
Foreign language	16
Computer science	6
Military training	2
Ethics	2
Law	2
Physical education	4
Labor	1
Employment counseling	1
Education courses	9
Teacher's oral language	11
Mathematical analysis I	6
Analytical geometry	5
Advanced algebra I	6
Mathematical analysis II	6
Programming language	5
Mathematical analysis III	4
Advanced algebra II	5
Functional analysis	4
Differential analysis	4
Advanced geometry	4
On probability	4
Elementary algebra research	3
Elementary geometry research	3
Mathematics pedagogy	3
Contemporary algebra	4
Computation methods	4

Table 4(…cont'd)

Course	Credit
Teaching practice	18
Graduation thesis	6
Elective courses	
Courses for enhancing cultural quality (like advanced Chinese)	8
Marxism and Leninism	4
Education courses	2
Subject matter electives	12
	Total: 189
Required elective courses	
Foundation mathematics	
Real analysis	4
Differential geometry	4
Fundamental number theory	4
Applied mathematics	
Operational research	4
Mathematical statistics	4
Mathematics education	3
Psychology of mathematical learning	3
History of mathematics	3
Education measurement and statistics	4
Applied secondary mathematics	3
Mathematics methodology	3
Optional elective courses	
Foundation	
Topology	
Applied mathematics	
Chaos theory	3
Mathematics modeling	3
Econometrics	3
Probability and statistics	3
Graph theory	3
Linear programming	3
Statistical software	3
Forecast and decision-making	3
Mathematics education	

Table 4 (...cont'd)

Course	Credit
Secondary school mathematics competition	3
Mathematics and logic	3
Spatial graph making	3
Education technology	3
English	
Practical English	3
Specialized English	3

With the institutional reorganization, the Mathematics Department of STU was renamed the School/College of Mathematics Education. As another mathematics educator of STU noted, the re-nomination shifted the focus from mathematics to mathematics education. One of their prominent efforts to make this shift of focus is seen in their 2-year (1997-98) experiment with an extended half-year student teaching practice.

Highly discipline-based, preservice training programs in China have historically treated student teaching practice as a chance to get a feeling *(gan jue)* about teaching (more will be discussed in the coming section). In 1997, STU felt inadequate in their capacity to train teachers who would be able to nurture children's creativity and application as demanded by the new reform. They no longer felt secure when some local schools tried to take "new blood" by starting to employ graduates from strong comprehensive university programs. They launched an experiment that extended the length of practice teaching to half of a school year in three big departments, Chinese, Mathematics and Physical Education.

According to an administrator who was responsible for student teaching at STU, the experiment aimed at three objectives: to strengthen students' ability to make and apply computer software in mathematics classroom; to train research ability by collecting data from their own teaching experience; and to learn how to become a homeroom teacher by working closely with their homeroom teacher mentors (they have a subject-specific mentor too). Another underlying objective was to build a sense of competition in their students and allow students and schools to know about each other.

The extended practice turned out to be a powerful experience for all student teachers. In our interview with a group of them in May, 1999, we were impressed with how strongly they felt about their experiences. Those who went to schools with a teacher shortage had their own class to teach *(ding gang shi xi)* and got paid enough to cover living expenses. To them, they got a real taste for being a school teacher. They enjoyed the freedom of making some teaching and management decisions and had a sense of independence. Those who followed other teacher's classes also felt that they learned a lot from their mentors and applied what they learned at STU to their own teaching. All of them admitted they had had no big difficulties with the mathematics subject matter they taught but encountered huge and unexpected problems with how to motive children to learn, how to handle with their psychological problems, and how to get to know about their students (in the mathematics pedagogy class, a special part is designed to help with how to learn about and understand secondary school students). They gained some research experience as well and compiled a volume of their research reports written on the basis of their teaching experience. Upon completing student teaching, most of them were hired by their practice schools to teach after graduation.

The duration of student teaching has been a longstanding issue for initial teacher training in China (see the discussion that followed). For a lot of reasons, it remains unsettled. Although there are things still need to be learned around this issue, we are aware of the cultural assumptions that make it an unsettling part of teacher education in China. It is widely held that preservice training is to train disciplinary specialists who are expert at mathematics, and learning to do real teaching can happen in the many years to come when graduates are rooted in daily practice. Through this new and short-lived experiment happened in a period of reform, it contains many stories about the twists and turns in the development of teacher education in China.

New balance of mathematics and mathematics education
-- linking science and technology with mathematics education

Mathematics and mathematics education are balanced differently in the two institutions. STU lays stress on the education part in an effort to develop its role in teacher education while ECNU endeavors to maintain its academic and research ground to enhance competitiveness with stronger comprehensive universities like Jiaotong and Fudan. With the implementation of a national teacher certification program, the so-called key universities are increasingly entering the labor market for teachers.

Where to go? The competition for a share in the labor market has roused the originally "care-free" preservice institutions to action. They are responding to new demands for mathematics disciplinary construction targeted toward academic and research capacity building and mathematics education at both ECNU and STU. And in both institutions too, actions have already been taken and initial achievements made in linking science and technology with mathematics education.

Preservice teacher education students at ECNU and all students of mathematics at STU are required to be able to design and use mathematics education "lesson software" (*ke jian*) to connect learning of mathematics with computer technology. It is worth noting that the pressure for applying computer technology with mathematics education again comes more from bottom-up, the local schools rather than from top-down, the policy level. An introductory class is already a required component of the secondary school curriculum. Meanwhile, as computers are increasingly popular in local households and many local schools, especially the key schools are better equipped in technology, school youngsters very often have access to more expensive PCs and accessories and more exposure to use new learning software than their teachers. In our interview at the Mathematics Department of ECNU, an administrator compared the technology gap between their teacher education program and the local schools in a joking but serious manner: "it is simply not going to work if we sounded like 'bumpkins visiting the big city'" (Interview, ECNU, 10-99).

Our observations of teaching at local schools impressed us that quite a few young teachers are using software they designed to teach their geometry classes in a quite effective way. School administrators invariably have high expectations on their young teachers to design and use computer software for teaching mathematics lessons. The knowledge and skills that young teachers demonstrate in bringing new technology into classroom are acknowledged as what the experienced teachers have to learn from their young colleagues.

B. The Relationship of Theory to Practice

Analysts of teacher education often use the language of dilemmas. Given the charge of preservice teacher education—preparing beginning teachers typically in some institutional setting—and the limits associated with it—for example, temporal, bureaucratic, logistical, intellectual, and other—the practice of preservice teacher education is one characterized by dilemmas. Many are familiar across time and local (or national) context. Perhaps one of the most familiar such dilemmas is what typically is described as the tension between theory and practice. Teacher education is a time for intending teachers to gain some combination of deep understanding of bodies of knowledge relevant to the work of teaching: subject matter knowledge, knowledge of learners and learning, knowledge of pedagogy and subject-specific pedagogy, knowledge of schooling as an organized system, and so on. Yet teaching is of course a practice, and in most societies, Shanghai included, there has been a traditional assumption that some part of learning to teach involves experience in practice. Traditionally this gets described as applying theory to practice. More recently teacher educators talk about practice not as a place in which to "apply" theoretical knowledge, but a site for inquiry and knowledge construction. "Knowledge-in-action" (Schon, 1983) becomes a kind of understanding developed only in practice, not something that is simply a translation of a disembodied theoretical abstraction.

The tension between theory and practice is a real one for mathematics teacher education in Shanghai. It can be understood in part in curricular terms, but also through the perspectives of teacher educators, their students, and practicing teachers.

Curricular expressions

The two universities in Shanghai which prepare secondary mathematics teachers differ in traditional and current arrangements for teacher preparation. Again, we need to look at the share of student teaching hours in the curriculum. ECNU, historically the higher status institution (with central government support, an academically higher achieving student intake, more visible research program, and a portion of its graduates who went into tertiary teaching, graduate study, or research rather than secondary school teaching), has 6 credits devoted to practicum experiences. In contrast, STU, which historically has been the major provider of teachers for Shanghai's secondary schools, expects 18 credits be spent in practica. But lest these seem like significant differences, when considered against the background of a student's total teacher preparation experience, both universities make "practice," as understood in formal practica, a small portion of a student's education: at ECNU, only 6/156 or 3.85% of total credits, while at STU, though larger, still only 18/189 or 9.52% of the total. (Refer to Table 3 & Table 4).

Both universities, despite their differences, struggle with finding a satisfactory curricular relationship between theory and practice. In part, this is expressed in terms of the amount of time given to practicum, as suggested above. Debates about the appropriate length of practicum have been persistent in Chinese discussion of teacher education (Paine, 1986). In recent years, for example, as mentioned above, STU has experimented with extending the practicum from a several week experience to a semester-long one and then scaled back to an 8 week experience. (ECNU continues to have a six-week practicum.)

The need to rethink the practicum is not only a matter of number of weeks. At STU, a central level administrator explained the challenge of attending to the range of learning the practicum is expected to support. He described three big pieces as all part of the practicum: teaching practice (*jiaoxue de shixi*), the practice of being the banzhuren (a teacher responsible for the pastoral care of a whole section of students, who must work intensively with them, understand their situation across the curriculum, and serve as the organizer of class activities and liaison with parents), and "educational investigation."

Figuring out a balance between university-based and clinical experience involves a process that reflects multiple pressures. The administrator claimed, for example, that "With the goal of quality education and the goal of training teachers for the 21st century, these demands are higher." At the same time, he explained that the extended student teaching experience gave STU students an edge in an increasingly competitive higher education market.

At STU, both the focus and control of the practicum has shifted from the conventional approach that dominated much of Chinese teacher education earlier. Now, as the administrator explains, "Some practica are in places we arrange, and some are in places the candidates arrange on their own." Thus, the tradition of a cohort of students going together to a school, closely supervised by university faculty, is not the model (Paine, 1990). In many cases current students from STU go to their practicum sites as the only student teachers in the building.

Another administrative change, with consequences for the goals of practicum, was addressed at STU: "Another change, within the practicum, we encourage a competitive consciousness. We want them to experience society's competition. Students have to find work now. The secondary schools get a chance through this to learn about a potential teacher, and we give the students a chance to learn about a school." Where student teaching previously was a highly supported, collective experience, one clearly separated from the centrally planned job placement system, today student teaching in Shanghai bears greater resemblance to U.S. students' experiences. Student teaching is not only a chance to develop skills and understandings, but a possible first step to a job.

STU's solution to the challenges of increased demands for developing a broader range of practical knowledge in teacher education has been not only to continually revise the length of the student teaching experience but also to create a new practicum sequence across the undergraduate program. According to one STU administrator:

Now based on the experiment of extending it [student teaching] to a semester, we've moved into a new revision of the practicum in which we developed a three- phase program. During the time from start of sophomore year till senior year is an observational period, when they need to understand the teacher. It is 20 hours a semester. This can be done either all at once or dispersed over time…[second is] The student teaching period—8 weeks, 7 hours a day, where they "learn to be a teacher" (*xuezuo jiaoshi*). [Last is] The research phase—10 hours. After the student teaching, to push higher, to learn things they haven't learned.

Continuity and Change

These curricular shifts and administrative changes give the impression of change. And certainly in terms of time, control, and formal curriculum, these are real changes. At the same time, the persistence of certain characteristics concerning the place of practice in the preparation of mathematics teachers suggests that the relationship of theory and practice remains a vexing one. Two features of practice stand out.

First, the notion of practice is one that gives relatively little time to actual instruction in a classroom. Despite the calls for increasing the length of the practicum, to outsiders from the U.S., it seems noteworthy that of the number of weeks in student teaching, for example, the actual amount of time in which a student teacher is teaching their students is quite limited. A STU senior this year who was completing her 8-week practicum, teaching high school mathematics, explained that the number of lessons for which she has responsibility was only 14. (The U.S. viewer "naturally" adds the adjective "only," but it should be noted that the description by participants does not give the length of time for instruction.) Compared to a decade ago, this marks a slight increase in the number of required lessons (or total class periods) a practicum student must teach. But to the outsider it is even more striking that the balance of time during student teaching is not spent in actual instruction, but in the preparation of one's own teaching and the observation of others (toward the end of supporting one's own). This notion—that the practical substance of "practice teaching," as it is called in Shanghai, is only partly direct instruction—is one with a long history in Chinese teacher education (Paine, 1990). It appears that this allocation of time reflects both understandings of what teaching is (e.g., it is more than face to face instructional time) and how one learns teaching (e.g., one learns by and through preparation and observation, as well as experiencing the doing of instruction).

Second, and equally persistent, according to our research, is the tension between valuing practice and valuing theoretical knowledge. When Paine first began research on teacher education in China in the early 1980's, interviews and research articles spoke convincingly of concerns about the limited time devoted to "practice" in the teacher education curriculum (Paine, 1986). As frustrated as teacher educators were with arrangements at the time, they felt they had little option, given the importance they gave to disciplinary knowledge and the theoretical understandings they felt were best provided through university coursework. As we listened to a group of mathematics department seniors at STU who had recently completed their practicum, they too voiced dismay at the university's decision to scale back the experiment in a semester-long student teaching. Yet, like the discussions first heard 20 years earlier, the arguments hinge on the dilemma of needing to provide sufficient support in university-based disciplinary work. To seniors who had experienced a semester-long practicum, returning to an 8-week experience seemed a loss. But for university faculty and administrators, STU's having a full semester devoted to student teaching means that its students have less time than ECNU students to develop the strong academic knowledge needed for mathematics teaching. As one mathematics educator expressed it, the students think what they lack is experience in working with students; they don't think they lack mathematics. By implication, he suggested they do.

ECNU which, for a range of complex reasons, has not experimented as greatly with expanding the actual practicum, still provides evidence of the dilemmas of taking practice seriously. There, mathematics educators discussed the problem of infusing their university courses with the practical. As a department administrator explained, despite reforms in the mathematics education offerings, there is a general lack of case-based teaching.

To review, then, while both STU and ECNU resolve the dilemma differently, both institutions' mathematics programs are grappling with how to make a place for practice in their teacher preparation program. Each has attempted reforms. At the same time, aspects of their programs also suggest persistent patterns in the definition of what constitutes practice and the arguments for why it is so difficult to give it its due in preservice training.

An interesting perspective on the challenges of reform comes from a novice teacher, a junior high mathematics teacher who is a STU graduate. Like all young teachers we interviewed (much like we would expect to find in interviews in the U.S.), she stressed that her student teaching experience was a powerful learning opportunity. But she analyzed the issues in ways differently from those in the midst of student teaching or those just completed with it but not yet graduated from university. From her perspective:

If I had not done the student teaching, I could not teach the way I am today. Whether it was one month or five months is not the issue, it is nothing versus something. In student teaching you are learning not in your own class. This is a developmental process, and then when you are a first year teacher you are learning in your own class. Starting in this sheltered way means that you don't have to learn everything at once.

Linking Preservice and Inservice

In the U.S., in discussions about the dilemmas of the relationship of theory and practice, one reason this dilemma takes the form and raises the concern it does is that preservice education is discussed on its own, as a freestanding experience. But as the teacher above suggests, if preservice education is only one stage in an ongoing learning experience, then the questions about the crafting of particular learning opportunities, while still important, change.

One can argue that the link between preservice mathematics teacher education and the early years of work and learning (induction) of a new teacher in Shanghai is a tightly coupled one. While preservice teachers get limited time in schools, in their university coursework they begin to study the curriculum that they will be teaching. Central to their work as future teachers is their understanding of what get called "important points," "difficult points," and "hinges" of teaching particular content. In their mathematics methods classes, preservice teachers, according to our interviews, have the opportunity to learn about these points and to begin to become familiar with the curriculum and its pedagogical requirements and/or implications. In our research, we see this as the beginning development of pedagogical content knowledge. This particular knowledge is regularly mentioned in our interviews with administrators and teachers as among the most important things new teachers need to learn. Thus, while the formal exposure to sites of practice (i.e., classrooms) is limited, the exposure to analytic skills and knowledge of practice—this pedagogical content knowledge—begins in the university, not in the formal "practice" in schools. It is reinforced during the practicum and then intensively focused on beyond preservice training, in the induction support of new teachers.

From this vantage point, there is a seamlessness in the preservice to inservice trajectory that may be missed if one only looks at formal curriculum regarding practica. At the same time, we heard in our interviews alternative perspectives. Certainly one of the most vocal of these came in an interview we had with a middle school leader. As an influential reformer and a school principal, he explained why he had recently hired two young junior high mathematics teachers whose training was not in STU or ECNU's mathematics departments, but in a preservice program for elementary teachers. From his vantage point, teacher education is out of step with schools, and teacher preparation serves as a conservative force by emphasizing disciplinary knowledge to the exclusion of attention to pupils' learning. He sought out graduates of elementary teacher education for their greater understanding of and attention to students. While his case was perhaps the most adamantly expressed, we heard others who echoed the sentiment of mathematics teacher education being out of step with new reforms, especially in "quality education" and, in learning the whole "fish" of mathematics, not just one portion.

C. Teacher education as conservator or change agent

This raises a third dilemma, which stood out in our interviews and observations. Here we speak of the tension between teacher education producing teachers for the schools of today and it developing reform-minded teachers for new kinds of teaching and learning. This issue is often understood as closely connected to the problems and promises of student teaching. Feiman-Nemser and Buchman (1987) discuss the ways in which student teaching is sometimes not teacher education, as experiences in the field challenge and subvert the educative experiences in teacher education classes. For mathematics teacher education in Shanghai, this issue takes on special salience, given the enormous scope of reform and the dazzling pace of change at certain levels.

Today, new teachers in Shanghai find themselves having to learn new metaphors for mathematics and for teaching. From central policymakers on down to school-level practitioners, we heard mathematics people invoke the metaphor of the fish to discuss how the teaching of mathematics is to change. Similarly, in school interview after school interview, we heard teachers and administrators talk about shifting teaching from teachers being in the lead to teachers playing the "guiding role," a metaphor for a version of practice that values active learning and student agency.

Yet as we visited mathematics departments at the two universities and met with new and experienced teachers in 13 secondary schools in five districts in the city, it is clear that the challenge for teacher education is a complex one. Mathematics programs, as described above, give relatively little time to courses that are practice-based. Yet the faculty often ascribe great value to the experience of practice. One ECNU mathematics educator whose class we observed commented on the impact of student teaching on the maturity of her students and the benefit to their thinking through problems of mathematics teaching. STU's student teaching now, according to administrators, provide a plan for the practicum to the host schools, but leave much of the responsibility to the school. In both these cases, as well as many other examples we heard, teacher education programs assume that there is much to be learned from the experience in schools.

In fact, the preparation of new teachers—both in preservice and induction programs—hinges on assumptions about the power of mentors and learning from models. In interview after interview with student teachers and new teachers, these young people would describe the powerful role their mentors play in shaping their practice. For many, their examples suggested that the mentors begin with assumptions of a version of mathematics teaching that maintains present practice. Mentors look closely at their novice's lessons, provide frequent feedback, and often make very specific suggestions. One STU student teacher, whose lesson we observed, for example, explained that in the case of that day's lesson, the mentor had made a couple of suggestions:

> He had asked me how I would talk about a particular problem and when I told him, he said think about a way that the students could come to discover this on their own, rather than my telling them. He'd suggested some way to highlight a point or help people notice something on their own, by my using red chalk in some parts of the work on the board.

Such level of detail seemed common among those we interviewed. In story after story, teachers talked about how their mentors shaped their practice. Of course, then, the complication comes when these models are exemplars of traditional practice, rather than reform-minded teaching.

In our Shanghai interviews with university-based mathematics educators, we found concern about the practice of mathematics education in Shanghai's schools and university programs. One person, clearly presenting himself as a critic, thinks a lot of new teachers are competent but feels that they could do almost as well with a little training (around teaching) right after high school. He is unsure about the value-added of university mathematics education. He doesn't know whether the problem is that university mathematics is no use or that these students (who become teachers) don't know how to make use of it. His criticism is of the ways in which mathematics as a field is defined: mathematics taught at the undergraduate level at university rarely reflects twentieth-century mathematics. He feels that reform is needed in both the university and schools. There needs to be reform in the university curriculum, but also school mathematics should reflect both more modern topics and methods (e.g. computer and calculator methods for solving equations).

A second mathematics educator has written extensively on the problems related to notions of mathematics learning. Three essays he has developed have as their titles: "practice makes perfect," "practice makes boring" and "practice makes stupid." He challenges widely held ideas about how students best learn mathematics (and the importance of drill and working towards fluency). He does not think he is alone in arguing for different approaches to mathematics education. He says that it is not that these new ways of teaching are not necessarily accepted by experienced mathematics teachers; it is instead the principals and the curriculum heads that are the conservative forces, and many of these are former mathematics teachers. (Certainly, we have many examples of this in our small sample.)

A third teacher educator stressed that what is translated as problem solving is really solving problems. She says Chinese classrooms have lots of emphasis on the latter, not the former.

These stories—of curriculum reform and of concerns about practice—suggest both the challenge of transforming mathematics education in Shanghai as well as the systematic nature of supportive structures to facilitate its development or reform. The weight given mathematics education and its reform is noticeable to an outsider. The elaborate mechanisms that keep the curriculum in place also stand as an important feature shaping the landscape any new mathematics teacher enters. These mechanisms shape much of the terrain of preservice teacher education and the practice it is to help develop.

III. Change: a discussion

In this paper, we consider three familiar dilemmas of preservice teacher education against a broad background of social and economic transformations. To meet the economic, political and social challenges, neither ECNU nor STU was found able to get rid of those perplexing dilemmas. Instead they have to manage them (Lampert, 1985). With still unsettled dilemmas, change nevertheless does occur. But as Tyack and Cuban (1996) suggest for the U.S., change does not always mean progress, and in Shanghai's education, it appears to be tinkering, by piecemeal and cyclical. As March (1981.) uncovered, change is also satisficing and solution-driven. Then what are the changes if there are any?

The most observable change is physical. Schools are relocated, merged or separated. Such mergers or separations took place in a cyclic way as a result of the changing education goals in the history of China. Teachers for decades received their initial training at teacher training institutions; and now they can receive it in comprehensive universities. In the landscape of teacher education, given the accumulative and slowly evolving nature of knowledge and practice, new change does not happen by canceling the old. Rather it tends to occur piecemeal, because organizations are satisficing by nature. They " seek alternatives that will satisfy a target goal rather than look for the alternatives with the highest possible value" (March, 1982). In the case of the two universities, they patched up a curriculum by adding the applied courses that the reform demands. They diversified course structures and offered more elective courses to widen student scope of knowledge. They managed with a limited practice teaching for decades because alternatives that entail more fundamental change are hard to make, given all the competing pressures on and within teacher education institutions.

In view of the current mathematics education reform, the change that is going to take place is strongly reflecting another nature of change defined by March: it is solution-driven. China is going to build up "minimal standards of mathematics learning" and turning mathematics into "mathematics of the masses" *(dazhong shuxue)* so that "everyone learns useful mathematics to his needs" (*Wenhui Daily*, 10-16-1999, p.1) so that not to impinge headache to all children with hard mathematics. These reform trends are or used to be part of the popular solutions to school mathematics in Western countries. They seem to match with the problems of mathematics in Chinese schools that the current reform aims to solve. Therefore, they are readily available for policy-makers in China to choose.

The danger of copying other's solutions blindly will not solve problems but may worsen them in the long run. For instance, the minimal standards may run the risk of being implemented as "top" standards. In so doing, people would end up with learning fewer mathematics. More people in China begin to view "quality education" (in mathematics education) in the form of a whole fish, a whole-process mathematics against the fragmented school mathematics taught without "head and tail". The consensus is that by restoring the head and tail, that is, by teaching children where mathematics comes from and how it can be applied to real life, children could become creative and have more application ability.

However, the school reform dilemma is that, even if everyone comes with a clear vision of what this whole fish of mathematics at school is or looks like (our ongoing research suggests that this is not necessarily the case), no one is yet clear about how this can be best taught or how to help teachers move out from their conventional practice into a completely new model of teaching. If school teaching and learning does not change, and if teaching and learning remains promotion- or examination-driven, and evaluation of learning is still based on grades alone, the reform change can not escape a piecemeal tinkering, and training children to be creative will still be utopia. A systematic reform has to be designed to bring up real change.

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