

The Cross-national Comparison of Pre-service Mathematics Teacher Education and Curriculum Structure

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This study compared mathematics achievement in China, Singapore and the United States. The results indicated that both the nations of the US and Singapore have enjoyed the same features, namely, that pre-service mathematics teacher- training mode transfers from closed development to an open one, from occupational orientation to professional development, from low level to high-level education; course structure from the over-emphasis on theoretical learning into a combination of theory and practice with equal emphasis, and education space from the stress on the university to cooperation with the primary and secondary schools. It is suggested to call for a reform in the depth of China's mathematics teacher education so as to train university students to become teachers who are well-informed, competent and thinking professionals.

Key words: mathematics teacher education, curriculum structure, professional development.

China's Pre-service Mathematics Teacher Education Program and Curriculum Structure

China's teacher education began rather late, since the Qing government in 1897 created China's first Normal School—Shanghai Nanyang Normal School^[1]. It has only a hundred years of history so far. At present, China's teacher education is in a centralized system under government administration and teacher training institutions are still independent from other institutions, which are set to train teachers in primary and secondary school. There are basically three teacher education programs in China for the pre-service preparation of primary and secondary teachers: Junior College, Undergraduate

and Masters. The Junior College program seeks to prepare teachers for junior and primary schools, while the Undergraduate and Masters Programs aim to train teachers for high school and junior school (with the continuous expansion of the job market of China's university graduates in recent years, the division has become increasingly ambiguous). Although the three teacher-training programs diversify in objective and content, they share more or less the same structure of curriculum, which is divided into compulsory modules and electives, and comprise four main areas of courses, namely, general culture courses, major courses, education courses and practicum (Chai, 2001; Chen, 2004; Li, 2004; Wong, 2002, 2003). Table 1 provides an overview of the curriculum structure of current mathematics teacher-training programs and Figure 1 & Figure 2 shows the proportion of hours and credits for Undergraduate programs.

Table 1
**China's Course Structure of Pre-service Mathematics Teacher
Education for Undergraduate**

Curriculum Structure	Course Types	Subject	Credits	% of Total Credits	Hours	% of Total Hours
Compulsory (2336Hours, 150Credits)	General Course	English, Sports, Politics, Law, Computer, National Defense, Humanities, Sociology, Arts, etc.	45	25	800	29
	Major Course	A Number of Math Courses	88	48	1296	45
	Education Course	Education and Pedagogy, Psychology, Educational Technology,	11	6.5	240	8

		Workshops, Internships, Thesis, etc.				
	Practice Course	Practicum (8-10 weeks in Year 4)	6	3.3	10 weeks	(6% of total weeks)
Elective (496Hours, 31Credits)	Major Elective	School Mathematics Research, Applied Math, Using IT for Teaching, Math History, etc.	21	11.7	336	12
	General Elective	Art, Music, Humanities subjects, etc.	10	5.5	160	6

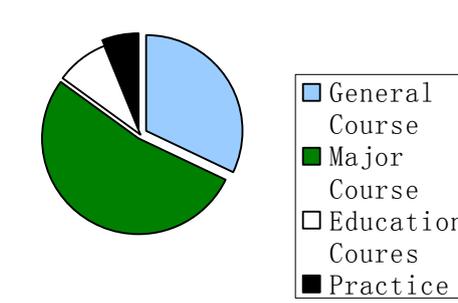


Figure 1. China's course structure and credits distribution for undergraduate.

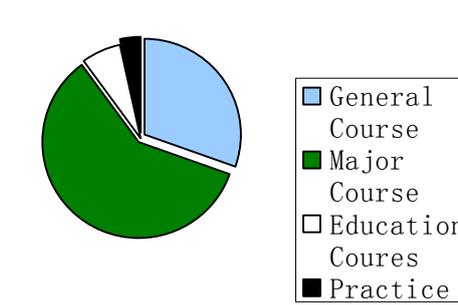


Figure 2. China's course structure and hour distribution for undergraduate.

In fact, Table 1 above also shows that general courses are completed over two modules totaling 55 credits and 960 hours. The compulsory courses accounting for 41 credits with 800 hours consists of physical training, English, computers, MA& Mao & Deng's Theory, low and other activity courses with 4 credits such as 2 weeks of national defense education ^[5] and so on, as well as elective courses totaling 10 credits with 160 hours, containing usual university level science, arts and humanities subjects. Major courses are composed of mathematics fundamental courses totaling 640 hours with 37 credits and mathematics trunk courses totaling 656 hours and 51 credits ^[4-6], as well as elective courses totaling 21 credits with 336 hours, which altogether take up about 59% of the credit units and 54% the total hours. Education courses with compulsory plus elective courses are 272 hours with 17 credits, take up 12% of the total credits and the total hours. Particularly, practical courses include teaching internship, education investigation, thesis and practicum, less than 6% of the total hours and 4% of the total credits.

In the new mathematics teacher education program which combines Undergraduate and Master with the "4 +2" mode, the course structure within the Undergraduate is still sorted by general courses, major courses, education courses and practical course program. Among them, general education courses account for about 27 % of the total hours, with major courses 58%, education courses 10% and practical courses 5%. The Masters section is composed of general education accounting for 20%, major courses for 20%, teacher courses for 36% and research methods and thesis for 24%.

To sum up, the pre-service mathematics teacher education in China is still trained-oriented and independent from school. Her main programs, especially for teachers in high school, are at a relatively low level. In the last decades, though curriculum structure and the teaching mode of teachers education has enjoyed an active exploration and reform, education courses and major courses are also the main focus of the reform, yet the long-standing problem of being rather theoretical and a lack of practice still exists. The curriculum structure, course objectives, teaching strategies and approaches merely transformed to a small extent. The area involved in general education courses are not only relatively narrow, singular and old, but also content-poor, with a low level of integration. The proportion of teachers' professional courses is too low and practicum is usually too short (8-10 weeks). The distribution of course and time is still not reasonable, especially in the Undergraduate program. Moreover, the shortage of pedagogical training and understanding of school mathematics curriculum is not obviously alleviated, which significantly curbs

the professional growth of these potential mathematics teachers and hinders them so they lack the capacity in education and teaching competence. All the above are very important for teachers to meet the constantly changing needs of the educational system in China. As a result, there is an urgent need for an effective balance in the distribution of time given to the learning of theories and principles and time for application and teaching strategies which are so necessary to the beginning teachers' immediate survival in the schools.

Singapore's Pre-service Mathematics Teacher Education Program and Curriculum Structure

Singapore is a city-state with no natural resources but is multi-ethnic and multi-lingual. In the short span of forty-odd years, Singapore has surprisingly developed into a country with advanced education and a modern nation, which all benefited from the fact that her government attaches great importance to education and talents. Her teacher education and mathematics education even draw the world's attention. Singapore believes that mathematical competence is the base and foundation of science and technological education for higher levels. The teacher education in Singapore is charged by the State Government Ministry of Education (MOE) and the unique teacher education institution, the National Institute of Education (NIE). Her teacher education system is under the "sandwich courses", meaning that the MOE will appoint candidates as General Education Officers immediately upon successful application. With untrained teachers, MOE will send candidates to NIE for some programs/courses. In exchange, the newly qualified teachers do not seek positions directly from the schools but are posted to the various schools by the MOE and bonded to serve the MOE for three or four years, depending on the teacher education program that they undergo^[8] (General Information 2003-2004).

The NIE offers basically four programs for pre-service mathematics teacher education, leading to a range of qualifications from Diploma in Education [Dip Ed] and Bachelor of Science (Education)[BSc(Ed)] to Postgraduate Degrees and only one program for secondary teachers. The last one is sub-divided into two specializations: Postgraduate Diploma for Secondary [or PDGE(S) in short] and for Primary [PDGE(P)]. These programs are designed to prepare trainees to become teachers who have the knowledge and skill to teach two secondary school subjects or alternatively two or three primary school subjects, depending on the specialization. Such

teachers will have an understanding of the key concepts and principles of teaching and learning and should be able to implement analyses and theories about key instructional process. They will be able to discharge competently their teaching responsibilities in a variety of classroom and school contexts in a professional and committed manner. They will also be committed to continual improvement and lifelong learning.

Among the four programs, there exist differences between each other in objectives and contents, while the curriculum structures are largely similar, all dividing content into core modules, prescribed electives and free elective courses. For instance, both PGDE(S) and PGDE (P) seek to train university graduates to teach two subjects which are determined by the MOE based on their undergraduate profession, and consist of four main areas of study: Education Studies, Curriculum Studies, Practicum, Language Enrichment and Academic Discourse Skills. Thus, each trainee is required to take two curriculum study courses, to prepare him/her to teach Mathematics and another subject respectively. During the one-year programs, each curriculum studies course takes up nearly a quarter of the total credit units, with another quarter going to education studies. The curriculum studies for mathematics teachers require 3 core courses as follows: The teaching of Mathematics I & II, Essential Mathematics for Secondary Teachers, totaling eight credits. In particular, the objective of Essential Mathematics for Secondary Teachers is to run in an on-line self-study mode where trainees are required to do independent learning of secondary mathematics topics using school textbooks and relevant materials. The courses do not account for credits, yet act as compulsory courses. The assessment for the module will be a mathematics test based on the 'A' level national examination. The teaching of Mathematics I & II is built on the foundation of modern cognition psychology, and combine theory of mathematics learning, curriculum theory, teaching theory and methodology as integrated curriculum, containing theory module, practice module and a number of topics ^[9-10]. It aims to encourage normal students to test the theory through practice, then reflect on and improve the theory to develop their recognition on the richness of teaching in education connotation, skills, methods, complexity, and creativity.

Education Studies is compulsory for all trainees, and both secondary and primary education require students to take 4 core courses (totaling 8 credits) as follows: instructional technology, social context of teaching and learning, the psychology of pupil development and the learning process, teaching and classroom management. In addition, the secondary education program also

sets up more than 20 prescribed elective courses such as the psychology of learning and motivation, understanding and helping gifted and talented pupils, understanding and teaching creative and critical thinking, computer applications in educational assessment, as well as 14 free electives like using IT for teaching and assessment, motivating students to learn and think, what it means to be a teacher, etc. The primary education program also sets up 25 prescribed elective subjects such as making learning interesting, teacher as researcher, assessment for effective learning, etc (PGDE, 2003-2004). Table 2 provides an overview of each program together with its curriculum structures, credit distribution and teaching practice duration.

Table 2
The Programs, Curriculum Structures and Distribution for the Pre-service Mathematics Teacher Education in Singapore

Program	PGDE(S)		PGDE(P)	Dip ED	BA/BSc(ED)
Duration of program	1 year		1 year	2 years	4 years
Curriculum structure and category	Education Studies and Credit Distribution	Core Subject 30% Prescribed Elective	Similar to the Case of the PGDE(S), 27%	Similar to the Case of the PGDE(P)	Similar to the Case of the PGDE(P)
	Curriculum Studies And Credit Distribution	Core Subject 61% Prescribed Elective	Similar to the Case of the PGDE(S), 50%	Similar to the Case of the PGDE(P)	Similar to the Case of the PGDE(P)
	Academic Subjects			Core Subject	Core Subject
	Practicum	Compulsory	Compulsory	Compulsory	Compulsory
	Language Enrichment Academic Discourse Skills	Free Elective	Prescribed Elective	Prescribed Elective	Prescribed Elective

Teaching Practice Duration and the Preparation of Hour	1 week in first semester. 9 weeks towards end of program. 34%	1 week in first semester. 9 weeks towards end of program. 34%	6 weeks in year 1. 7 weeks in year 2. 2%	2 weeks of school experience in each of year 1 and 2. 8 week of Teaching Practice in each of year 3 and 4. 17%
Total Credits	26	30		

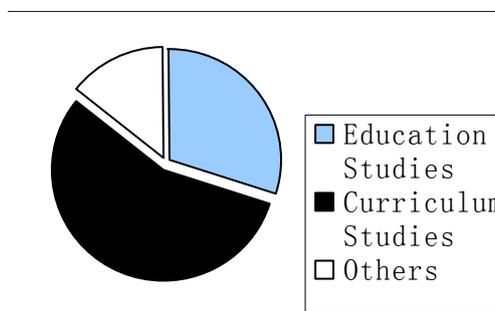


Figure 3. Singapore's course structure and credits distribution for PGDE(S).

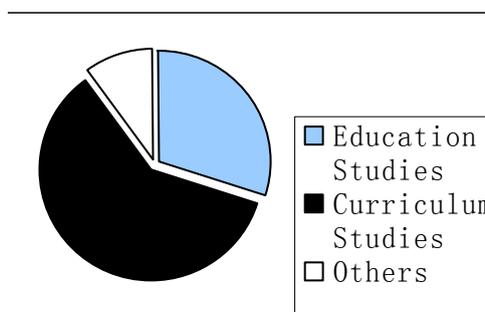


Figure 4. Singapore's course structure and credits distribution for PGDE(P).

According to the Suat (2003), the mathematics curriculum studies begin with a general overview of the aims and structure of the mathematics curriculum in the Singapore education system. Most of the course is taught in

groups of between 25 to 30 trainee teachers, enabling much discussion, reflection and collaborative learning. Each group is taught by one assigned instructor who takes the group throughout the course. General psychological theories for learning mathematics as well as lesson planning in general are also covered towards the beginning of the course. The majority of the course is spent on the teaching of the various topics in the school curriculum. Within broad strands of Arithmetic, Algebra, Graphs, Statistics, Geometry, Menstruation, Trigonometry and Calculus, trainee teachers will examine the understanding of some topics, specific learning difficulties, strategies and teaching approaches, the use of Information Technology, enrichment tasks, and methods for teaching difficult topics, etc. The course also includes practice sessions where trainees present mock lessons or parts of lessons to practice their planning and communication skills in explaining or developing a particular mathematics concept. The planning of these lesson segments could be discussed with instructors or course-mates prior to the presentation and reflection, and feedback and more discussion would be given after the sessions. Although error analysis of pupils' work may be done within the topics, the general procedures of setting mathematics examination and test papers and developing marking schemes are covered in general rather than topic by topic.

In the one-year PGDE(P) general program, which essentially stretches over 29 weeks, the mathematics curriculum studies has 3 core courses with 8 credits, taking up nearly 1 / 3 of the total credits including Principles and Practice of Primary Mathematics, Fostering Mathematical Thinking and Assessment in Mathematics. Apart from that, there are two curriculum study courses for English and either Science or Social Studies respectively, as well as nine elective courses containing science, society, art and music. Within this short-time frame, these prospective primary teachers take education study courses similar to the case of the PGDE(S) program, as well as undergoing 10 weeks of Teaching Practice. In the prescribed elective courses, there are Algebra, Statistics, Number Theory, Calculus, Computational Mathematics, Operations Research and other topics. The education study course in primary schools is similar to the one for secondary teachers. For instance, these courses do not only involve the psychology of learning mathematics, diagnosis and analysis of mistakes, measurement and evaluation of teaching, but also create a model with the application of calculations^[10-11].

Primary teachers of 4-year Diploma and 2-year Diploma in Education are enrolled through the Mathematics A-level national examination or through the Mathematics O-level national examination. Although they have different

school years lengths, both modules have similar course structures. The education studies for the Dip(ED) and B.A/B.Sc (Ed) programs are largely similar in content to that of the PGDE (P) although the contents are organized over different modules in each of the programs. Like the secondary mathematics curriculum studies, general learning theories and assessment modes are covered in addition to the pedagogical aspects of the various school curriculum strands: whole numbers, fractions, ratio, proportion, percentage, decimals and operations, space, data, etc. It also sets up discussions of teaching and simulation training. According to Suat (2004), because the trainee teachers are being prepared for the Singapore school system, there are also two specific topics which are peculiar to Singapore mathematics: trainees are trained to teach (a) the model method of solving word problems, where diagrams with blocks are used to represent unknown quantities, and (b) the use of the abacus for addition and subtraction. These two topics also highlight the ability to teach. Trainee teachers are also given time to present their teaching ideas and the assessment of their performances in these courses normally include individual as well as group assignments and projects. The practice sessions are about 20 weeks and 13 weeks respectively, and go throughout the entire study from the first school year probationary education and teaching practice

In each of the pre-service programs, Teaching Practice forms a crucial and substantial component. It does not count for credit, yet is evaluated by a special assessment level. During the Teaching Practice, the pre-service teachers are sent out to schools in Singapore and remain full-time in those schools for the whole duration of the Teaching Practice period. Initially, they are given opportunities to observe classroom teaching for about 2 or 3 weeks, after which they will teach classes assigned by the schools. During Teaching Practice, they are supported by both faculty members and practicing teachers who take the role of mentors. Language enrichment and academic discourse skills are free elective courses, most of which have no credit and are aimed at improving oral communication skills and writing skills (PGDE, 2003-2004).

Comprehensively speaking, we could find that Singapore's model of mathematics teacher education and curriculum structures has four distinct features: teacher education stressed as a profession to learn with the system of "first entry, then training", the combination of directional and non-directional mode, fostering pre-service mathematics teacher education for primary and secondary schools respectively in accordance with the pedagogy term, and curriculum that is serialized, modular and thematic. Focusing on the basis of

specialized courses, teachers should be concerned about the background of the Singapore Education system, with particular emphasis on educational practice to ensure that the prospective teachers are equipped with a dual profession. Closely connected to the content and structure of mathematic education, laws of cognition, educational objectives and teaching requirements, Singaporean teacher education aims to construct programs to strengthen the trainee teachers in academic subjects and mathematics teaching. It also enhances the integration of cooperative learning of teaching theory and practice with the importance of cultivation of reflective awareness.

The US's Pre-service Mathematics Teacher Education Program and Curriculum Structure

The United States has one of the most developed educational systems in the world. The teacher education for primary and secondary school is addressed in the colleges of education at universities. There are basically two teacher education programs, namely, Bachelor of Science (Education)[BSc(Ed)] ,and Masters (4+1).This two-level teacher education is also broken down into primary education and secondary education, Primary teachers are required to teach multiple subjects, while secondary teachers are specialized with one subject^[12]. Because the teacher education system of the US applies to decentralization of power, the teacher education curriculum in different states are similar yet have diversified features. The majority of the curriculum is separated as general, major and education, with a series of compulsory courses and electives. Table 3 provides a case of the course structure of mathematics teacher education from Wisconsin State for Secondary school (Wisconsin Standards for Teacher Development and License, 2000), while Figure 5 and Figure 6 shows its hours and credits distribution for the case.

Table 3

The US's Course Structure of Pre-service Mathematics Teacher Education for Secondary

Curriculum Structure	Course Types	Subject	Credits	% of Total Hours	% of Total Hours
	Liberal Studies	Strategies for Communication,	40	32.8	30

Compulsory	Courses	Philosophy, Literature, Art, Sociology, West History, Physics, Biology, etc.			
	Major Course	Various Mathematics Courses	36	30	30
	Education Course and Practice Course	Teaching Strategies, Youth Development Across the Curriculum , Schooling & Societies, Advanced Studies on School Mathematics1-2, The teaching of Mathematics1-2, Secondary Mathematics Research, Educational Psychology, Educational Technology, Understanding and Teaching Various Students,	29	22.5	27.5
		Practice in Secondary School	18	14.7	12.5
Elective	Others	School Mathematics, Music, Other History, Classroom Management & Discipline, Strategies and Assessment for Effective Thinking and Learning , Other History ,Sociology ,General Education, etc.			

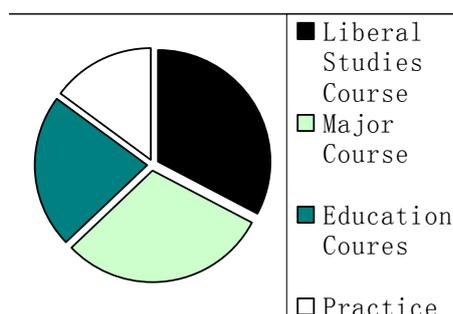


Figure 5. The US's course structure and hour distribution for secondary.

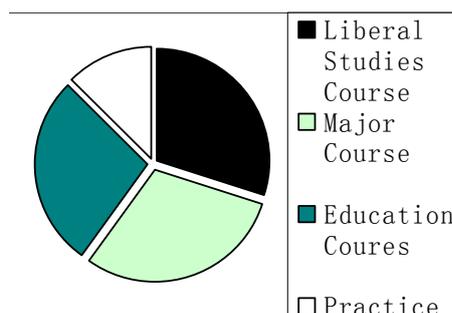


Figure 6. The US's course structure and credits distribution for secondary.

As mentioned above, we set forth the curriculum of BSc(Ed) from Wisconsin mathematics teacher education^[12] for secondary as an example. These pre-service teachers must take 122 credits to obtain a bachelor's degree. Throughout the program, liberal studies courses take up 40 credits with, major courses 36 credits and educational courses 46 credits. These trainees are required to take at least 9 credits in humanities, nature and social science respectively so as to ensure that they engage in a broad range of disciplines and enjoy a firm knowledge base. The majority of liberal studies courses involve nature, language, sociality, and art, humanities in a wide range of courses, such as strategies for communication, philosophy, literature, physics, biology, journalism, music, dance, drama, women's studies, Western history, and so forth. A major subject is an important part of mathematics teacher education courses. It requires candidates to complete 22 credits in mathematics in the first two years, and 14 mathematics credits afterwards. This is to ensure that normal students are familiar with the necessary professional knowledge of mathematics, understand the key concepts and structures of mathematics, experience and acquire the necessary and meaningful learning experiences in mathematics to achieve the professional standard for mathematics teachers in the United States and state standards for Teacher Certification.

Educational courses include educational theory, teaching strategies and techniques, as well as experience and skills gained through education internship, which is required to be completed in specified semester, and at least two semesters of practice must be at the secondary schools. A good many courses focus on the development of training and teaching knowledge, professional trends, skills and practical for ability, such as teaching strategies, youth development across the curriculum, advanced studies on school mathematics, the teaching of mathematics, understanding and teaching various students, human capacity and learning, classroom management and discipline,

strategies and assessment for effective thinking and learning ,which are compulsory for all trainees who will teach mathematics.

Take the education and social services programs of the University in Vermont College as an example for primary education^[13]. The course structure is similar to the case for Secondary Education. The 4-year 127 credits consist of elective courses plus compulsory courses. In the first 2 years, study is concentrated on natural science, humanities and social science, similar to general subjects in secondary schools education. Three teacher education courses are compulsory, children and learning, teachers and teaching, society and school. Later on it strengthens teacher education courses year after year; academic subjects with teaching methodology are intertwined. The key is to learn the educational knowledge and skills and match the psychological structure and development level of pupils.

The "4+1" Model of the Masters is primarily open to graduates from a non-educational profession who wish to specialize in the teaching profession in the fifth year. The program generally requires at least 30 credits, of which 2 / 3 are teacher education courses, whereas 1 / 3 are concentrated in the scientific areas of teaching, with emphasis on teaching research and practice^[13-15]. These students are required to understand how children learn, grasp the laws of child development, and apply a variety of teaching strategies. They also have to develop communication, collaboration, management, education, teaching methods and the ability to deepen their teaching and foster a sense of reflective practice. They will also be committed to continual improvement and lifelong learning.

In conclusion, there are two chief levels for mathematics teacher education in the USA at the Undergraduate and Masters levels. Though the curriculum model is flexible and diversified, it attaches great importance to the coordinated development of general education, academic education and teacher education. With the solid foundation on professional subjects of normal students, it also highlights the point that teachers should have more extensive knowledge and vision towards educational psychology, educational technology, understanding various students and other professions. It combines the characteristics of student background with the influence of families and communities to develop and train the student. The course structure is developed modularly, and is integrated and professional. With professional teacher education theory and practice, many universities in the USA have created professional teacher development schools in cooperation with primary and secondary schools and established a partnership to promote teaching

ability. These measures strengthen the teachers' professions and practical capacity so that teacher education enjoys revolutionary changes and students obtain a broad range of knowledge about pupils, schools, families, communities, culture, and educational background from theory to practice. Thus, it effectively meets the professional development needs of pre-service teacher education.

Conclusion

In terms of the training mode, Singapore and China both have three types of educational levels, i.e. vocational student, undergraduate and masters. Singapore combines directional and non-directional training modes, and sets standards for a high-level postgraduate diploma for primary and secondary mathematics teachers. In the United States, pre-service mathematics teacher education is separated into undergraduate and graduate, with a high-standard, non-directional mode. The trainings for primary and secondary schools are cooperatively and openly developed. The mode in China is still independent, directional and undergraduate orientated, but in recent years it has launched the Masters of Education. Above all, the mathematics teacher training model has improved from the closed stage to an open one, from the low-level to a higher standard, from vocational orientation to professional education. To improve the quality of teacher education has become an international trend.

In terms of curriculum structure, Singapore's mathematics teacher education courses are offered mainly through curriculum studies, educational studies and educational practice. Teacher education is highlighted as a profession to learn and it pays special attention to theory and practice to understand and master the process and the law of education, with a focus on research and teaching practice. In the United States and China, mathematics education is divided into general courses, major courses, education courses and teaching practice, whereas the United States attaches great importance to the coordinated development of the four series of courses. On the basis of math-oriented professional quality, it places particular emphasis on academic education and teaching practice, providing a broad range of general knowledge. Both Singapore and the US's courses for pre-service mathematics teachers have evolved in the last few decades from being rather theoretical and psychology-based to a combination of theory and practice. In comparison, mathematics teacher education in China has evolved much to meet the constantly changing needs of the educational system. However, due to the

profound influence of traditional attitudes and behavior, there is still too much emphasis on academic courses with the lack of educational studies, too much knowledge-centered learning and too much stress on theory without enough attention to practice, as well as the course content failing to match the actual curriculum reform in primary and secondary schools of the nation.

In terms of content selection and teaching method, the United States and Singapore's teacher education have transformed from a stage of over-emphasis on knowledge and learning theory into one of the cooperation between theory and practice. They attach great importance to the practice and application of the course content and teaching theory. The United States not only requires trainees to spend two semesters on secondary education internship, but also sets up courses such as *Schools and Society*, *Reading and Writing in Secondary School Curriculum*, *Research on Secondary School Mathematics*, and *the Teaching Practice* with close links to secondary education curriculum. In comparison, Singapore closely attaches the mathematics curriculum syllabus of primary and secondary school and the implementation of teaching materials to the integration of disciplines and teaching. Based on this multi-dimensional learning, analysis and research, the curriculum studies put focus on enhancing students' understanding of the nature of education and mathematics methodology, as well as improving practical teaching capacity. The educational system of both the US and Singapore stress the cooperation between primary and secondary schools, and highlight the role of educational personnel in teacher training and professional development. The teaching approach is turning from a teaching - training model to a reflective practice model. These areas are the blind spot of China's mathematics teacher education and teaching reform.

The pre-service education of China's mathematics teachers will have to be developed to meet not only the internal changes in the teacher educational system, but also the revised mathematics syllabi for primary and secondary schools. There is a need for an effective balance in the distribution of time given to the learning of theories and knowledge of mathematics and time for practical ideas and teaching strategies so necessary to the beginning teachers' immediate survival in the schools. So, while trainee teachers are given a basic understanding of the learning theories, a large part of the course should discuss the applications of these theories in teaching strategies as they apply to various topics in the mathematics curriculum. The most important content to strengthen the reform of mathematics teacher education and the teaching mode in China is to provide normal students with extensive background knowledge,

to focus on equitable distribution between academic courses and education studies, and to strengthen the professionalism, application and practice of the educational curriculum.

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