Teachers' knowledge: Review from comparative perspective

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Abstract

Background: The international science competitions show that students from different countries perform differently in subjects such as mathematics, physics and chemistry. In the literature comparative empirical studies tried to address the reasons for cross-national students' differences in performance from different perspectives such as teaching strategies, learning environments, curriculum and policies. However, one important area that shapes students' intellectual development is ignored in comparative study: teachers' knowledge, which eventually decides how effectively teachers teach and how well students learn.

Focus of discussion: This study intends to focus on the differences between Chinese and American contexts and development of their teachers' knowledge with a greater emphasis on China. Without considering the different types of professional knowledge the teachers in these two countries possess, simple comparison of students' performance on the tests makes little sense and without considering how the teachers develop their professional knowledge, we cannot determine the primary reasons that contribute to the differences in students' performance.

Suggestions: The development of teachers' knowledge is context-sensitive and a deep analysis of the context will offer a clearer picture of what teacher knowledge really is. Thus comparative studies need to look at the difference in students' performance from the perspective of educational philosophy, contexts and policies.

Conclusion: If we attribute Chinese students' higher performance on tests to teacher knowledge, we first need to define the validity of the Chinese teachers' knowledge. The fact that Chinese students are excellent performers on tests does not mean they will eventually turn out to be real scientists. So far no scientists from mainland China have ever won the Nobel Prize for science. Because teachers' knowledge is either positively or negatively correlated with students' performance, to explore how teachers' knowledge has developed and under what context will reveal more meaning regarding what kind of knowledge their students have learned and a study of this kind has more practical significance for policy makers and educators.

Keywords: teachers' knowledge, comparative study, China and the United States

教師知識：從對比的視角評述

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摘要

*背景：*國際科學競賽顯示不同國家的學生在數學、化學和物理等學科其表現是不同的。以往的對比實證研究在教學策略、學習環境、課程設置和政策等方面對差異的原因進行分析探討。然而，教師知識，一個對學生智力發展起關鍵作用的領域，卻在對比研究中被忽視，而教師知識卻決定了教師有效的教學和學生有效的學習。

*討論焦點：*本研究旨在關注中國和美國環境和其教師知識發展的關係。如果不考慮兩國教師專業知識，簡單的對比學生考試表現其意義並不顯著，而如果不考慮教師如何發展其專業知識，將無法瞭解到促使學生不同表現的真正原因。

*建議：*教師的知識發展與環境息息相關，深入分析環境將更清晰地勾勒出教師知識的原貌。因此，對比研究應該從民族文化、教育理念和政策等方面分析學生表現出的差異。

*結論：*如果把中國學生在考試中高分表現歸功於教師知識，我們應該界定中國教師知識的內涵。中國學生的高分表現並不表明他們將最終成為真正的科學家。迄今中國大陸還沒有一位科學家獲得諾貝爾獎。因此探究教師知識的發展及其發展環境將有助於瞭解學生獲得的知識。這類研究對政策制定者和教育工作者更有現實意義。

關鍵字：教師知識，對比研究，中國與美國

Introduction

The study of teachers' knowledge has occupied a significant position in the research of teacher education for the last 25 years (Borg 2003). Teachers' knowledge is defined as knowledge exclusively applied to teaching (Shulman 1987), and it is believed to play a decisive role for effective teaching (Grossman 1990). In contrast to the popularity of research within one educational system, teachers' knowledge draws less attention in the field of comparative study. The primary reason for me to study teachers' knowledge derives from statistical reports about the performance of Chinese and American students in international science competitions such as: International Mathematical Olympiad (IMO), International Chemistry Olympiad (IChO), International Physics Olympiad (IPhO) and International Biology Olympiad (IBO)[1]. In all of these annual science competitions the Chinese students always rank higher than their American peers. For example, in IChO, Chinese high school students ranked first from 2002 to 2008 except in 2005 and American counterparts were left far behind in 10th place. In IPhO, for the last 10 years, China earned a total of 38 gold medals while the U.S. earned only 18. A quick conclusion that Chinese students are smarter or more diligent than the American ones reveals little meaning, and it is necessary for us to first look behind these statistical figures and explore what factors have made such a difference, especially comparatively studying the education in the two countries. In the literature there are comparative studies focusing on this area such as teaching strategies (Andrews 2007), learning environments (Akiba 2008; Lamb and Fullarton, 2009), curriculum (Wang and Santos 2003), and policies (Webster, Young and Fisher, 1999). However, in regard to teachers' knowledge in terms of comparative study, especially between China and the United States, research is limited to mathematics at the elementary level (Ma, 1999; An, 2004). Researchers believe that teachers' knowledge plays a decisive role in teaching effectiveness. Shulman (1985) points out that "to be a teacher requires extensive and highly organized bodies of knowledge" (p. 47) and Elbaz (1983) puts even more emphasis on teachers' knowledge by stating that "the single factor which seems to have the greatest power to carry forward our understanding of the teacher's role is the phenomenon of teachers' knowledge" (p. 45), which is believed to be contextually bound and is developed and shaped through teaching experience (Clermont et al. 1994). My literature review targets the development of teachers' knowledge in the two countries, China and the United States. Studies indicate that Chinese teachers hold a different understanding of subject matter knowledge (Ma, 1999) and their professional knowledge also develops in different curriculum and teaching organization (Wang & Paine, 2002). However, in the few comparative studies available, no researchers, if any, have ever touched upon how the Chinese environments nurture teachers' knowledge. Considering the fact that China has the longest continuous history in the world and different political and economic situations, teachers' knowledge acquired under such environments is assumed to be different from those that develop in the American context.

Because teachers' knowledge, as an integrated set (Shulman, 1986), develops in a wide teaching contexts that are related to different factors (Lee et al, 2007), I try to cover the factors, whether cultural, historical or political, that contribute to the development of teachers' knowledge. With the purpose of initiating deeper and broader comparative study on the development of teachers' knowledge

in different teaching contexts between China and the United States, I select the few related articles available in the literature for a review.

What makes up teachers' knowledge

It used to be believed that if someone knew a subject he was well qualified as a teacher to teach the subject (Shulman, 1986). For example, in the late 19th century, the California State Board examination for elementary school teachers only tested basic knowledge about arithmetic, grammar, history, etc. and thus, based on this kind of examination, said Shulman (ibid), the judgment of a qualified teacher depended primarily on subject matter knowledge. The depressing result of such judgment is a false assumption that everyone can teach as long as she/he knows the subject. Against this mistaken belief, in the late 19th century, Dewey (1902) advanced the theory that teachers should psychologize the subject matter knowledge. He explained that two intellectual planes were involved in the understanding of subject matter knowledge, the logical and the psychological. The logical referred to the subject matter per se and it was the representation of knowledge held by experts or specialists. It was the abstracted framework of a subject. The psychological aspect, on the other hand, was concerned with the children's interests and experiences associated with the subject. In an earlier article *"The Psychological Aspect of the School Curriculum"* (1897), Dewey clarified the relationship between the logical and the psychological:

> From the psychological standpoint, we are concerned with the study [of subject-matter] as a mode or form of living individual experience. Geography is not only a set of facts and principles, which may be classified and discussed by themselves; it is also a way in which some actual individual feels and thinks the world. It must be the latter before it can be the former. It becomes the former only as the culmination or completed outgrowth of the latter. Only when the individual has passed through a certain amount of experience, which he vitally realizes on his own account, is he prepared to take the objective and logical point of view, capable of standing off and analyzing the facts and principles involved. (pp. 168–169).

Dewey pointed out that teaching was a process that was far more complex than the transference of knowledge from a teacher to learners. By mentioning child's interests and experiences, Dewey drew the focus of teaching to learners. To "psychologize" subject matter knowledge, as Dewey termed, meant that teachers should understand learners, and to understand learners was prerequisite to learning. In the Child and the Curriculum, Dewey (1902) delineated the proper role a teacher was supposed to play:

> Hence what concerns him as teacher, is the ways in which that subject may become part of experience; what there is in the child's present that is useable with reference to it; how such elements are to be used; how his own knowledge of the subject-matter may assist in interpreting the child's needs and doings, and determine the medium in which the child should be placed in order that his growth may be properly directed (pp. 242–243).

Dewey's conception was further developed more than 80 years later when Shulman reexamined

teachers' knowledge in the form of pedagogical content knowledge. Shulman (1986) found that earlier conceptions of teachers' knowledge were problematic. He cited two examples. One, as mentioned earlier, was the California State Board examination for elementary teachers in 1875. It intended to elicit only teachers' understanding of subject matter knowledge such as written arithmetic, written grammar and history of the United States, etc. Another case Shulman cited was today's state tests for teacher's licensure. He found that in most states, evaluation of prospective teachers eliminated subject matter knowledge and in its place teaching procedures such as organization and classroom management dominated. The two extreme examples showed either subject matter knowledge was treated almost exclusively as what teachers were expected to know or pedagogical knowledge was regarded as sole representation of professional knowledge for teaching. Against this situation, Shulman raised two fundamental questions concerning teacher development and education: Where do teachers' explanations come from? How do teachers decide what to teach, how to represent it, how to question students about it and how to deal with misunderstanding?

To address these questions, Shulman and his research team explored the knowledge of secondary novice teachers teaching English, biology, mathematics and social studies in a year-long study by observing their classes and interviewing them. Shulman categorized teacher's knowledge as content knowledge, pedagogical content knowledge and curricular knowledge. For teachers' content knowledge, Shulman referred to it as "the amount and organization of knowledge per se in the mind of the teacher" (1986, 9), which, he explained, was more than the understanding of subject matter like biology held by a major of biology. Teachers are expected to understand not only what it is but why it is so and how to justify their belief about their understanding. As for pedagogical content knowledge, Shulman defined it as "the subject matter knowledge for teaching", which included how ideas were represented and made comprehensible to learners. Shulman also added the understanding of learners as an important component to pedagogical content knowledge because, as he put it, students were not likely to appear as "blank slates" (p. 9). The third category of teachers' knowledge was curricular knowledge, which, Shulman described as "the materials for that instruction, the alternative texts, software, programs, visual materials, single-concept films, laboratory demonstrations…" (p. 10).

Following Shulman's pattern, Grossman (1990) explored teachers' knowledge by conducting a case study of six novice English teachers. She compared two groups composed of three teachers each. In the first group, the three teachers didn't receive formal teacher education and had to largely depend on "their disciplinary knowledge of English to inform their pedagogical decisions" (p. 19). In the second group the three teachers were graduates from a teacher education program and applied what they had learned "in constructing their conceptions of the purposes and appropriate practices for teaching English" (p. 85). Grossman argued that teachers needed to reconsider "their subject matter from a more pedagogical perspective" and the conception of understanding subject matter knowledge from the pedagogical perspective couldn't develop automatically. She believed that teacher education was essential to develop teachers' knowledge, which, as she conceptualized, included subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge and knowledge of context. Grossman's categorization generally matches Shulman's division

but she added one more component to the knowledge base, knowledge of context, which she defined as, "knowledge of the districts in which teachers work, knowledge of the school setting, knowledge of specific students and communities, and the students' backgrounds, families, particular strengths, weaknesses, and interests" (p. 9).

Analyzed from a different perspective, Cochran-Smith & Lytle (1999) classified teachers' knowledge into three major kinds: knowledge-for-practice, knowledge-in-practice and knowledge-of-practice. In this chapter article of position, the authors elaborated the three conceptions of teachers' knowledge. In their analysis, they integrated the construction of knowledge base with its development. Shulman presented a general picture on how teacher knowledge was constructed and Grossman investigated how teachers developed their knowledge. Different from the prior researchers, Cochran-Smith and Lytle examined the relationship between knowledge and practice by including all components in a general category.

The first conception of knowledge for teaching, as the authors defined, was made of "formal knowledge," or "the general theories and research-based findings on a wide range of foundational and applied topics that together constitute the basic domains of knowledge about teaching, widely referred to by educators as 'the knowledge base'" (p. 254). In it, the authors incorporated the components of teachers' knowledge as Shulman (1986,1987) and Grossman (1990) classified such as "content or subject matter knowledge as well as knowledge about the disciplinary foundations of education, human development and learners, classroom organization, pedagogy, assessment, the social and cultural contexts of teaching and schooling" (p. 254). This type of knowledge, as the authors stated, was learned through formal channels such as preservice and teacher development programs. It is ready made for teachers to acquire and put into teaching practice, which is "a process of applying received knowledge to a practical situation" (p. 257) because there are "empirically verified strategies for classroom management, instruction, curriculum, and assessment that transcend differences in local contexts and hence require minimal translation by teachers for use in classrooms" (p. 261). This theory seems to echo Grossman (1990)'s argument that teacher educators need to consider both subject matter knowledge and pedagogical content knowledge. The second conception of knowledge for teaching was knowledge-in-practice, a kind of knowledge that was "acquired through experience and through considered and deliberative reflection about or inquiry into experience" (p. 262). The experience, as the authors exemplified, included "facilitated teacher groups, dyads composed of more and less experienced teachers, teacher communities, and other kinds of collaborative arrangements that support teachers' working together to reflect in and on practice are the major contexts for teacher learning in this relationship" (p. 263). Different from the first two conceptions that distinguished formal knowledge and practical knowledge, the third conception, knowledge-of-practice, described a situation where teachers first found "both knowledge generation and knowledge use are regarded as inherently problematic" (p. 272) and thus they have a different relationship to knowledge, and knowledge for effective teaching derives from "systematic inquiries about teaching, learners and learning, subject matter and curriculum, and schools and schooling" (p. 274).

In sum, the construct and development of teachers' knowledge involve factors that go beyond empirically-verified formal knowledge and practical knowledge acquired from teaching experience. From

Dewey to Cochran-Smith and Lytle, the nature of teacher knowledge is always open for discussion. However, the agreement among them is that teachers' knowledge is multidimensional and disregard of any components will distort a true picture of what teacher knowledge really is. If teachers' knowledge is studied comparatively between two countries, what needs to be taken into consideration is the context. According to Grossman (1990), knowledge of context includes communities, students' background and families. If we examine it from a larger perspective, factors like educational system, culture and values are also important ingredients that should be taken into account.

What are valued in Chinese and American education

One of the simple ways to compare the effectiveness of teachers between two educational systems is to examine how students from each country perform on comparative competitions such as International Science Olympiad. But the results are far from enough to justify what good teaching is. As it has been mentioned earlier that teachers' knowledge is a decisive factor that determines what kind of knowledge students may acquire, it is necessary to delve inside the hidden reasons in terms of teachers' expertise. Sanders et al (1998) found both Chinese and American mathematical teachers held similar beliefs that teachers' competence was closely related to their students' success. They surveyed 79 fourth-grade Chinese teachers and 29 American peers and found that both groups saw teachers' competence as an important influence on their students' performance and both groups rated their competence of teaching mathematics as average or above average. But, in their study the authors didn't make it clear which specific competence both groups of teachers held respectively. This question was addressed in Ma's study (1999), which compared the understanding of mathematics between Chinese and American teachers. Her comparative study focused on the research questions concerning the role teachers' content knowledge played in teaching, whether teachers' level of content knowledge played an important role and whether teachers should take further courses in order to improve this knowledge. She interviewed 23 American teachers who all had BA degrees and at least one year of study in teacher education programs and 72 Chinese teachers who received the nine-year mandatory education and two to three years of teacher education at a normal school. In the interview, Ma implemented four common elementary topics that were believed to be accurate representations of teachers' subject matter knowledge of mathematics: subtraction, multiplication, division by fractions, and the relationship between area and perimeter. She discovered a sharp contrast in the teachers' understanding of mathematical content. Although American teachers had received a minimum of four years in higher education, they showed a limited and even wrong understanding of mathematical concepts but their Chinese peers, who received less formal education, demonstrated a wider and deeper understanding of the same concepts. One of the differences Ma found in the Chinese teachers was the way they understood mathematics. For example, the Chinese teachers often quoted a saying "know how, and also know why". This concept actually reflected a Chinese ancient educational philosophy: teachers were supposed to clarify doubts. The Chinese teachers also encouraged students to work on math problems with alternative solutions. Actually this practice reflects a teaching philosophy: Confucius recommended in the Analects, in which Confucius said that learners should draw inferences about other cases from one instance.

In another comparative study between Chinese

and American mathematical teachers, findings also revealed that both groups were significantly different not only in subject matter knowledge but also pedagogical content knowledge. An et al (2004) collected data from 33 Chinese and 28 American mathematical teachers by sending questionnaires, observing some teachers' classes and interviews. All the Chinese teachers, similar to the participants in Ma's study, received three-years of education at normal schools plus the nine-year mandatory education and all the American teachers had a bachelor degree or above. They focused on one part of pedagogical content knowledge, knowledge of understanding students in four areas: "building on student ideas in mathematics, addressing students' misconceptions, engaging students in mathematics learning, promoting student thinking about mathematics" (p. 168). In helping students develop mathematical concepts and procedures, 51% of the Chinese teachers attached importance to conceptual understanding while only 29% of American teachers believed so. The authors also found that the American teachers tended to use concrete and pictorial ways to represent mathematical concepts. In addressing students' misconceptions, most Chinese teachers were likely to ask appropriate questions to find out each individual student's understanding but 79% of American teachers didn't do so. To engage the students in learning how to multiply fractions, Chinese teachers tended to use two representations while American teachers chose to use one, a similar approach found by Ma (1999). Another contrast is that Chinese teachers (45%) were good at integrating the students' prior knowledge but only a small number of American teachers (7%) did so. Finally, both groups used different ways to promote the students' thinking about mathematics. Chinese teachers tried to develop the students' abstract thinking but American teachers depended on concrete methods such as using charts and tables.

Ma and An et al's research show that Chinese teachers have a wider and deeper understanding of math concepts and teaching strategies but why and how they gain a different understanding from the American teachers is a question we inevitably will ask. According to Grossman (1990), American teachers should be better qualified because they received more formal teacher education training and are supposed to know more about the subjects they teach. Both Ma and An et al's findings challenged Grossman's conclusion and extended our insight of teachers' learning beyond formal teacher education or what Cochran-Smith and Lytle (1999) called knowledge-for-practice. But how knowledge-for-practice together with knowledge-in-practice can be converted into knowledge-of-practice is a question that should be addressed for any practical application in the development of teacher's knowledge.

To explore this question, Wang and Paine (2003)' s case study may shed some light. In order to explore the questions about what teachers learn through contrived curriculums and teaching organizations and how the curriculum and organization influence the development of teachers' professional knowledge, they observed and interviewed a novice teacher in a Chinese middle school. The case was actually part of a large data set in a comparative research project aiming at "understanding how middle grade beginning teachers learn to teach mathematics in different national contexts" (p. 79). They suggested that with the help of a mandated curriculum and a contrived teaching organization, teachers could "develop quality teaching practices based upon well-articulated teaching objectives, reasoned representations of content taught, and considerations of what students have learned and what they are going

to learn" (p. 91). They also argued that mandated curriculum materials could encourage teachers to set clear objectives in accordance with the professional standards and that contrived teaching organizations facilitated teachers' interaction and teamwork in understanding curriculum and preparing lessons.

The research by Ma (1999), An et al (2004) and Wang and Paine (2003) all focused on the knowledge of Chinese mathematics teachers. Ma explored teachers' subject matter knowledge and she concluded that the supportive factors that develop Chinese teachers' mathematical knowledge are not found in the United States". Some of the supportive factors were discussed in Wang and Paine's research as they attempted to find out how mandated curriculum and contrived organization helped to develop the teacher's professional knowledge. The result of the development under such contexts is the different structure of pedagogical content knowledge presented in An et al's study. Chinese teachers put more stress on students' conceptual understanding of mathematics by relying on traditional and rigid procedures while the American teachers encouraged students' creativity and inquiry by using various activities (An et al, 2004). If we look beyond the campus and examine the hidden social and political perspectives, we can conclude that the different contexts in the two countries led to their different levels of professional knowledge.

From Eckstein and Noah (1993)'s book, we may find some more clues for the reasons why Chinese teachers demonstrate different professional knowledge. The authors compared school exit examination systems in eight countries including the USA, China, Japan, Germany, England and Wales, France, Sweden and the former Soviet Union. From them I selected USA and China for comparative review. On the American side, the authors chose two grade 12 students, Peter and Marylou. Even in the last year of high school, the two senior students didn't face pressure to prepare for any college entrance examinations. They enjoyed extracurricular and sport activities and social life. They were supposed to take tests such as the Scholastic Aptitude Test (SAT) that was recommended or even required by universities, but "high scores alone do not guarantee admission" (p. 35). Besides, the students could retake the test in subsequent months if they were not satisfied with their scores. For Peter and Marylou and their classmates, college or universities were not the only choice. 40 percent of their classmates had decided to go to community colleges for vocational courses. The high school where Peter and Marylou were studying was a resourceful learning context. It provided adequate space for academic and extracurricular activities and facilities such as a swimming pool and a sport field. The school also had funds for computers and the latest textbooks. Under the American educational system, federal government has little power in decision making. Public schools are governed by locally elected school boards and funded by local tax revenue. In contrast, the two Chinese grade 12 students, Mei-ling and Wei-lun, experienced an entirely different senior high school life. Historically, China suffered a continuous lack of material resources and consequently all students dreamed of "golden rice bowls", a promising future that could help the young people "join the small, highly educated leadership cadre" (p. 57). The university entrance examination was highly competitive and only 2 to 3 percent of those who entered elementary schools would finally take the examination. So the last year in high school for Mei-ling and Wei-lun was an ordeal. They studied for long hours and focused their attention only on those things that would be tested on the examination. Because of

a lack of resources and time, even classes for science experiments were dominantly "chalk and talk" (p. 56). They had no time or opportunities to pursue their interests and participate in extracurricular activities. Neither had they the luxury to retake the high stake examination, for it was only administered once a year and the "odds against success are great" (p. 56). In spite of the severe criticism against the present assessment system, the government still adhered to it simply because it "greatly reduced the risk of overt favoritism, influence-peddling, and corruption in the location of university places" (p. 57). Study by Liu and Meng (2009) also reveals students' test scores are a very important indicator for good teachers. Liu and Meng compared the characteristics of good teachers' in China and the USA and they found that a good teacher was roughly the same according to indicators that mostly overlapped in the two countries. These indicators included such things as the teacher as a person, classroom management and organization, planning and organizing for instruction, implementing instruction, and monitoring student progress and potential (p. 324). Among them, however, one difference stood out: students' test scores, which listed as one of the most important indicators for a good teacher in China but was ignored or not seen as very important by American students and parents.

With the different situations in the two countries, it is not hard to figure out some of the reasons why American and Chinese teachers demonstrate different professional knowledge in mathematics in both depth and breadth. If we focus on the findings by Eckstein & Noah (1993) and Liu & Meng (2009), we may easily jump to the conclusion that it is environmental pressure rather than teachers' knowledge that shapes the ultimate outcome of Chinese students' performance. Shulman (1986) pointed out that teachers' knowledge is composed of various sources including understanding learners. They adjust their teaching according to learners' needs and prior knowledge. Indeed, the high pressure from the high stakes college entrance examinations is equally experienced by teachers, who regularly attended meetings held by the teaching research group to discuss ways of improving students' examination scores (Wang & Paine, 2003). It is the objective shared by both teachers and students that push teachers to cultivate their professional knowledge and this shared objective is primarily set for the college entrance examination (Eckstein & Noah, 1993).

It is the same developmental pattern of teachers' professional knowledge that brought about an ironic finding in English teaching in China. The Chinese teachers teaching English, though naturally much lower in English proficiency than native English speaking (NES) teachers , were more welcome than the NES teachers by the Chinese students (Simpson, 2008). In his article of position, Simpson (2008) analyzed the reasons of the conflicts between the Chinese students and NES teachers who taught English in China. The conflicts included communicative language teaching (CLT) such as a student-centered interactive format and the traditional Chinese method (TCM) such as a teacher-centered lecture format. By reviewing the literature regarding English teaching in China, he found that TCM was still dominant in English classrooms in China and the introduction of CLT met hard obstacles because Western educational theories such as 'autonomy and egalitarianism, self-reliance and individualism' (Li, 1994, p. 84) ran counter to Chinese teacher-student relationships and also because the university entrance examination, as Eckstein and Noah (1993) discussed earlier, served as "gatekeepers to success more than assessors of success" (Simpson, 2008, p. 385). Inevitably, the fierce competition in entrance

examinations would find its way into the curriculum, which is based on knowledge rather than skills because "knowledge bits are more easily tested than skills are" (p. 388). This is one explanation for Wang and Paine's conclusion that mandated curriculum helps "teachers develop the necessary professional knowledge for teaching" (Wang & Paine, 2003, p. 75).

Simpson (2008) concluded that successful teaching depends on a real understanding of the teaching context and it is in this very context that the Chinese teachers in the study by Ma, An et al and Wang and Paine cultivated their knowledge for teaching.

To conclude what has been reviewed in this section, it can be seen that comparative studies between teachers' knowledge such as the elementary mathematics teachers (Ma, 1999; An et al, 2004) only examined the superficial differences. We need to take a more insightful approach to explore the context of where the professional knowledge was developed. Wang and Paine's research tells us curriculum and teaching organization make a difference. However, from a macroscopic view, we need to broaden our study to examine it from the perspective of national culture, educational philosophy and policies in which the curriculum and teaching organization are situated.

Conclusion

With all the statistical figures showing that Chinese students always outperform American students in the international science competitions, I inevitably raise the question of why has not a single Chinese scientist from mainland China won the Noble Prize in science?. But ironically, as of 2009, half a dozen Chinese scientists who are living and studying abroad got the prize in either physics or chemistry[2]. If we attribute Chinese students' higher performance in international science competitions to teachers' knowledge, it seems that we first need to define the validity of the knowledge. Is it the knowledge that better matches the questions in science competitions? Are American students more capable of independent thinking and analyzing because their teachers are more likely to use creative and inquiry-based teaching (An et al, 2004)? Shulman (1987) pointed out that the key factor to define a teachers' knowledge base lies in the ability of how teachers can transform the content knowledge into "forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students" (p. 15). Chinese mathematics teachers showed a different understanding of subject matter knowledge (Ma, 1999; An et al, 2004) from their American peers. This kind of knowledge, apart from the development of formal teacher education, is further strengthened and enriched in real teaching context (Wang & Paine, 2003), which "psychologizes" teachers' subject matter knowledge (Dewey, 1897) and makes it "subject matter knowledge for teaching" (Shulman, 1986). In short, under different contexts, both Chinese and American teachers' knowledge-of-practice (Cochran-Smith & Lytle, 1999) is presented in different forms and contents. With a good understanding of the type of knowledge Chinese and American students receive at school, we need to consider what kinds of people the students from the two countries will eventually turn out to be. Chinese high school students taught by Chinese teachers with their knowledge perform well in international science competitions but will any of them eventually win the Nobel Prize or turn out to be accomplished scientists? Do they also need some other knowledge that is not found in the knowledge system of Chinese teachers but is available for American students? Questions

such as what type of teachers' knowledge that is helpful to make real scientists in the future are worth further study because they are not only significant for policy makers and educators but also for the national scientific development.

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Notes

[1] Retrieved from http://olympiads.win.tue.nl/

[2] As of today the following Chinese scientists living and studying abroad were awarded Nobel Prize

In physics:

1957: Chen Ning Yang, Tsung-Dao Lee (Chinese American)
1976: Samuel C.C. Ting (Chinese American)
1997: Steven Chu (Chinese American)
1998: Daniel Chee Tsui (Chinese American)
2009: Charles Kuen Kao (Spending his childhood in Hong Kong and Studying for undergraduate and graduate degrees in Britain)

In Chemistry :

1986: Yuan Tseh Lee in Chemistry (born in Taiwan. Studying as a graduate and working thereafter in the U.S.)
2008: Roger Tsien in Chemistry (Chinese American)

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http://wiki.answers.com/Q/How_many_Nobel_prize_winners_are_Chinese_by_ethnic_or_by_nationality

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