Comparative Studies on U.S. and Chinese Mathematics Learning and the Implications for Standards-Based Mathematics Teaching Reform

Author(s): Jian Wang and Emily Lin

Source: *Educational Researcher*, Jun. - Jul., 2005, Vol. 34, No. 5 (Jun. - Jul., 2005), pp. 3-13

Published by: American Educational Research Association

Stable URL: https://www.jstor.org/stable/3700061

Comparative Studies on U.S. and Chinese Mathematics Learning and the Implications for Standards-Based Mathematics Teaching Reform

by Jian Wang and Emily Lin

Chinese students often outperform U.S. students on international tests in mathematics. Chinese students' mathematics performances are assumed to be related directly to their teachers' deep mathematics understanding and ability to represent concepts flexibly in their classrooms, which, in turn, are thought to be influenced by Chinese mathematics curriculum and policies. The authors examine this theoretical assumption through a systematic review of relevant literature and attempt to identify the relationship between Chinese students' mathematics performance and the factors that contribute to their achievement. On the basis of their review, the authors raise questions about the assumption and propose research that can lead to a better understanding of the relationship between the quality of students' mathematics learning and the contexts in which their learning occurs.

Since the late 1980s, various U.S. professional organizations have focused on the development of two major policy initiatives intended to transform teaching culture and practices, with the primary aim of improving learning for all students in the nation. Some groups have developed curriculum and teaching standards to project a new image of teaching to guide teachers and, at the same time, hold them accountable (National Council for the Social Studies, 1994; National Council of Teachers of English & International Reading Association, 1996; National Council of Teachers of Mathematics, 1989, 1991, 2000; National Research Council, 1996). Other organizations have attempted to change the ways in which teachers work with each other and to engage teachers in developing subject-specific pedagogy that aligns with the standards (Holmes Group, 1986, 1990; Interstate New Teachers Assessment and Support Teaching Consortium, 1992; National Council for Accreditation of Teacher Education, 1999).

Despite various criticisms of these reform approaches (Apple, 2001; Berliner & Biddle, 1996; Cochran-Smith & Lytle, 1999), advocates of these policy initiatives were motivated by and are continuing to rely on international and comparative studies to sustain or further develop their efforts, especially in mathematics education (Romberg, 1997, 1999). Several reasons are clearly behind the advocates' persistence: First, a series of large-scale studies showed that U.S. students underperformed in various international tests in contrast to their East Asian counterparts (Beaton, Martin, et al., 1996; Beaton, Mullis, et al., 1996; Robitaille & Garden, 1989; Stevenson & Stigler, 1992).

Educational Researcher, Vol. 34, No. 5, pp. 3–13

Second, substantial differences exist not only in curriculum policies and materials (such as content coverage, instructional requirements, and structures) but also in how the policies and materials are developed and implemented in the United States and in top-performing East Asian countries (Lewis, Tsuchida, & Coleman, 2002; Mayer, Sims, & Tajika, 1995; Schmidt, McKnight, Cogan, Jakwerth, & Houang, 1999; Tsuchida & Lewis, 2002). In particular, in comparison with the top-performing countries, U.S. curriculum materials are less focused and more repetitive, and U.S. curriculum policy is less authoritative, less specific, and less consistent (Cohen & Spillane, 1992).

Third, teachers in the top-performing countries not only develop a better understanding of subject matter content, as reflected in their curriculums, but also are more likely to demonstrate their flexible representation of such understanding in their classrooms (Ma, 1999). In addition, these teachers are more likely to provide clearer explanations, make more efficient use of their class time, and engage students in inquiry by using whole-class pedagogical techniques (Linn, Lewis, Tsuchida, & Songer, 2000; Perry, 2000; Stevenson & Lee, 1995; Stigler & Hiebert, 1999). Furthermore, teachers in these countries are organized to study the curriculum and plan lessons together, observe and critique each other's teaching, and analyze student learning collaboratively, activities that presumably further shape their teaching knowledge and practice (Lewis, 2000; Lewis & Tsuchida, 1998; Paine, 1997; Paine & Ma, 1993).

Overall, on the basis of the aforementioned research findings, an assumed positive relationship between student performance and curriculum standards, teaching organization, and teachers' knowledge and practice emerges. However, such an assumption, derived from international comparisons, is not unquestionable. Fierce debates about the use of these comparative studies have focused on several issues: whether the statistical differences between the mathematics performance of students in the East Asian countries and that of U.S. students are important, whether sampling for the comparisons has been representational, and how the differences should be interpreted on the basis of various statistical lenses

(Baker, 1997; Bracey, 1993, 1996, 1997a, 1997b, 1999, 2000a, 2000b; Romberg, 1990; Stedman, 1997a, 1997b; Stevenson, 1993a, 1993b).

Although these debates are important, they have several limitations. First, many are based on ambiguous cross-national categorizations of East Asian students from Japan, China, Korea, and other East Asian regions and countries with little differentiation among them. Such ambiguous categorization is problematic considering that conceptual, institutional, and practical differences exist among those countries (Tobin, Wu, & Davidson, 1989). Similarly, U.S. students are often categorized as a homogeneous group without consideration of the similarities and differences among racial groups. For instance, findings on the performance of Asian Americans rarely distinguish among those whose ancestors are Japanese, Chinese, Korean, Vietnamese, Cambodian, Thai, Hmong, Laotian, Filipino, and so forth. Such broad categorizations may mask underlying ethnic and cultural differences and thus prevent adequate interpretation of differences related to student performance.

Second, a deep knowledge of mathematics on the part of Chinese teachers (Ma, 1999) may not necessarily lead to the same type of teaching practices as those demonstrated by Japanese teachers, who may have acquired a different understanding of school mathematics (Hiebert & Stigler, 2000; Stigler, Fernandez, & Yoshida, 1996). The type and focus of mathematics discussions found in Chinese and Japanese classrooms also vary across national lines (Lewis & Tsuchida, 1998; Wang & Paine, 2003). When lesson study—a professional development approach that originated in Japan—was transplanted to U.S. schools, the nature and dynamics of the teachers' discussions about their teaching were changed dramatically (Fernandez & Chokshi, 2002). These studies suggest that mathematics teaching in different cultures can be culturally scripted and that therefore mathematics learning in may be culturally rooted (Stigler & Hiebert, 1999). Thus the simple transplantation of a particular kind of teaching practice or professional development approach from one country to another may not be useful in producing similar student performances without careful consideration of the cultural tradition and foundation upon which the practice or approach was conceived, developed, and implemented.

Third, many of these debates center around the comparative differences in students' *overall* scores as measured by various sets of tests in the top-performing Asian countries and the United States. Little attention is given to developing a refined understanding of performance differences in *specific* areas of mathematics competencies, especially those areas emphasized in U.S. mathematics curriculum and teaching standards. For instance, although Chinese students routinely outscored U.S. students *overall,* were superior in tasks involving computation skills, and were more efficient in routine problem solving, U.S. students performed as well as or better than their Chinese peers on more open, creative problem-solving tasks (Cai, 1997, 1998, 2000). The reasons underlying these differences have seldom been explored or carefully analyzed. Moreover, the higher general performance, greater computational skills, and superior routine problem-solving skills demonstrated by Chinese students do not necessarily translate into better performance in divergent and open-ended problem solving—skills that are deemed critical in U.S. mathematics curriculum and teaching reform. Hence, the potential effectiveness of emulating Chinese instructional practices to improve U.S. mathematics performance in specific competency areas is questionable. Despite the lack of direct research evidence, a relationship between the specific types of pedagogical practices and particular kinds of mathematical skills or performance in the Eastern Asian countries, such as China, is often assumed. Clearly, extensive research is needed in these areas to inform the debate.

Fourth, arguments frequently focus on comparisons between U.S and top-performing countries, with little attention to comparisons between U.S. and low-performing countries. For example, when the Third International Mathematics and Science Study (TIMSS) reported that the top-performing countries such as Japan, Korea, and Singapore routinely implemented a common, centralized curriculum system, whereas U.S. schools used a decentralized curriculum system, many naturally assumed that a centralized curriculum contributes to improved teaching and better student performance (Schmidt et al., 1999). However, this assumption is easily countered with a careful examination of other low-performing countries, such as Romania, which uses a centralized curriculum but whose students performed much less well than U.S. students.

Fifth, these debates often concentrate on curriculum and teaching practices and their impact on student performance by comparing U.S. students with those in top-performing countries as national groups. They pay less attention to various types of nonschooling factors and their interaction with schooling factors that influence students' mathematics performance. When reports showed that students in East Asian countries, such as China and Japan, outperformed U.S. students, many scholars readily looked to differences in teaching and curriculum in various countries as explanations for performance gaps (Stigler, Lee, & Stevenson, 1987; Stigler & Stevenson, 1991). Often neglected is the consideration that Asian American students are also good performers in mathematics and that they, along with other U.S. peer groups, are exposed to the same types of U.S. curriculum and teaching practices. Therefore, a careful comparison between students in top-performing Asian countries and their peers in U.S. schools is necessary. This not only will allow for close scrutiny of the assumption that schooling is the only contributing factor to students' higher performance but also will provide opportunities to explore the influences of nonschooling factors.

In this article, we examine both schooling and nonschooling factors that affect student mathematics learning through a careful and systematic analysis of studies that focus on comparisons between Chinese and various groups of U.S. students. We chose Chinese students as a basis for the comparison because they consistently rate among the top mathematics performers in international comparisons and because many studies are developed to compare Chinese and U.S. student mathematics performance through examinations of both schooling and nonschooling factors. We analyzed the theoretical assumptions and findings of those studies and raised questions about the gaps and contradictions in the literature. On the basis of these analyses, we hope to clarify some of the contentious issues and assumptions surrounding current U.S. reform, policies, and practices, and we propose additional research that is needed for further clarification.

How Well Do Chinese Students Outperform U.S. Students?

Comparison Between Chinese and U.S. Students

Studies comparing the mathematics performance of Chinese and U.S. students extend from first grade to high school, cover various geographical regions in each of the two countries, involve a large number of participants (Chen & Stevenson, 1995; Miura, Chungsoon, Chang, & Okamoto, 1988; Stevenson, Lee, Chen, Lummis, et al., 1990; Stigler, Lee, & Steven, 1990), and use various measures of mathematics performance. The measures of performance are drawn from school curriculum-based examinations, U.S. standardized mathematics tests, and researchers' self-designed assessments (Gu, 1997; Huntsinger, Jose, Larson, Krieg, & Shaligram, 2000; Stanley, Huang, & Zu, 1986; Stevenson & Stigler, 1992). Collectively, these studies can be used to represent the range of situations in both countries and to address various kinds of mathematics competencies.

The insights that we gained through our review include three major findings. First, Chinese students outperformed their U.S. counterparts in the areas of base-ten counting and place values (Miller & Stigler, 1987; Miura et al., 1988), calculation and mental mathematics (Brenner, Herman, Ho, & Zimmer, 1999; Cai, 1997; Geary, Bow-Thomas, Fan, & Siegler, 1993; Gu, 1997), simple and process-constrained problem solving, and flexible mathematics representation (Brenner et al., 1999; Cai, 1995, 1997, 1998, 2000; Cai & Silver, 1995; Stevenson, Lee, Chen, & Lummis, 1990; Stigler & Perry, 1988).

Second, these advantages of Chinese students over their U.S. counterparts appeared in children who had not yet begun formal schooling (Geary et al., 1993; Geary & Liu, 1996; Ho & Fuson, 1998; Miura et al., 1988; Miura, Okamoto, Kim, Chang, Steere, & Fayol, 1994) and continued through the middle and high school levels (Brenner et al., 1999; Cai, 2000; Chen & Stevenson, 1995; Stanley, Huang, & Xu, 1986). Some studies suggest that the achievement gap in some of these areas became even more pronounced between Chinese and U.S. students as they moved from first- to fifth-grade levels in their respective school systems (Stevenson & Stigler, 1992; Uttal, Lummis, & Stevenson, 1988).

Third, although Chinese students showed superiority to U.S. students in symbolic and abstract thinking, Chinese students show no advantage in graphing, understanding tables, or open-process problem solving (Brenner et al., 1999; Cai, 2000; Miura et al., 1994; Stevenson, Lee, Chen, Lummis, et al., 1990).

Comparisons Among Chinese, Chinese American, and Other U.S. Student Groups

Although an extensive number of Chinese–U.S. comparative studies exist, studies specifically comparing Chinese students, Chinese Americans, and other U.S. racial groups are limited. In general, the samples for these studies are small, ambiguous in identifying students with Chinese ancestry, and limited to a narrow range of grade levels. Therefore, caution should be observed in generalizing the results.

These studies are conducted along two lines of research, providing some interesting findings. First, the comparison between Chinese Americans and other American racial groups suggests that within the U.S. setting, Chinese Americans outperform Caucasian Americans in mathematics skills as measured by standardized mathematics aptitude tests and that such differences are held constant as children move from kindergarten to fourth grade (Huntsinger et al., 2000). Chinese Americans are also better mathematics performers than other Asian Americans when measured by their school grades (Blair & Qian, 1998).

Second, studies that compared Chinese and Asian American students, which largely consisted of Chinese Americans, suggested that Chinese elementary and high school students often outperform their Asian American counterparts. In turn, Asian Americans were better performers than other racial American groups as measured by school curriculum–based examinations (Chen & Stevenson, 1995; Stevenson, Lee, Chen, & Lummis, 1990).

These findings on student performance may offer alternative explanations that diverge from the commonly assumed positive relationship among mathematics curriculum, teaching setting, and student mathematics performance which underlie current U.S. mathematics education reform initiatives. That is, because the research revealed that the mathematics performance gap between Chinese and U.S. students widened as they moved from first to fifth grade (Stevenson & Stigler, 1992; Uttal et al., 1988) and because the Chinese students seemed to perform better than other Asian Americans (Chen & Stevenson, 1995; Stevenson, Lee, Chen, & Lummis, 1990), the implication is that Chinese schooling may contribute to better Chinese student performance.

However, the existing literature also showed that Chinese students are better performers than their U.S. counterparts in mathematics even before formal schooling (Geary et al., 1993, 1996; Ho & Fuson, 1998; Miura et al.,1988, 1994) and the performance gap between Chinese Americans and Caucasian Americans also increases as both groups move through U.S. schools (Huntsinger et al., 2000). These critical findings suggest that the widening gap between Chinese and U.S. students may not necessarily be attributed to formal Chinese schooling because Chinese American students may not have been exposed to any type of formal Chinese schooling influences. Rather, the increased gap between Chinese and U.S. students and that of Chinese Americans and Caucasian Americans may be due primarily to the nature of their initial gap prior to formal schooling, such as counting efficiency and base-ten number sense. These advantages of Chinese and Chinese American students may very well contribute to their better mathematics performance in relevant areas of mathematics.

In addition, the assumption that Chinese schooling may contribute to better Chinese student performance is further challenged by other important review findings. For instance, Chinese Americans with little or no influence from formal schooling in China outperformed not only Caucasian groups but also other Asian American groups (Blair & Qian, 1998). Furthermore, the determination of whether Chinese students actually outperform Chinese American students is still unresolved because American students with Chinese ancestry are often categorized as "Asian American" in these comparative studies. More convincing evidence might be gained if Chinese Americans were clearly distinguished from the general category of Asian Americans, if specific levels of exposure to formal Chinese schooling were controlled and examined, and if larger numbers of participants from different grade levels were involved in comparative studies. However, even if these types of studies *were* conducted and the findings indicated that Chinese students outperformed Chinese Americans, the differences attributed to Chinese formal schooling effects alone would still be unexplained. That is, as Chinese American students become progressively acculturated into American society, many of the social and cultural influences that enhance their mathematics performance may be reduced or even disappear.

Moreover, research findings indicate that although Chinese students generally outperform U.S. students, Chinese students do not necessarily perform better than American students in some of the competency areas demanded by U.S. mathematics curriculum and teaching standards, such as mathematics reasoning, communication, representations, and problem solving. For example, although Chinese students are stronger than U.S. students in abstract mathematics reasoning and representation, Chinese students do not show stronger performance in graphing, using tables, and open-process problem solving.

Overall, comparative studies between the mathematics performance of Chinese and U.S. students showed that the mathematics learning of Chinese students could be influenced by a variety of factors, including formal schooling. However, the existing studies alone do not conclusively identify the specific factors or how they influence mathematics learning between Chinese and U.S. students. To better understand these factors and their influences, more refined and focused comparative studies are needed that examine Chinese, Chinese American, and other American groups and their exposure to formal Chinese schooling and performance in the areas of mathematics competencies as emphasized by the U.S. mathematics curriculum and teaching standards. In addition, further studies should explore the factors in and outside school contexts that may directly affect Chinese and U.S. students' mathematics learning.

What Influences Differences in Mathematics Performance?

Influence of Teaching-Related Factors

The overall better mathematics performances of Chinese students as compared with their U.S. peers have lead some scholars to focus on differences in classroom practices as explanations for the disparity. Several Chinese–U.S. comparative studies examined the nature of teachers' mathematics knowledge, their lesson organization, and classroom instruction.

First, following the tradition of process–product research on instruction (Brophy, 1989), some researchers observed and analyzed the patterns of instructional organization and interactions between students and their teachers in elementary mathematics lessons. They attempted to establish a relationship between student mathematics performance and teacher behaviors/lesson organization by using large numbers of lesson observations, mainly at the first- and fifth-grade levels in both countries.

Drawing on the observation data from 12 students and their teachers in two first- and fifth-grade mathematics lessons in 10 schools in Japan, Taiwan, and the United States for 2 to 4 weeks, Stigler and Perry (1988) found that Chinese students spent substantially more time on learning activities led by their teachers than did their U.S. peers. Chinese teachers were more likely to use whole-group instruction to present information, engage students in practice, and offer feedback to students, whereas U.S. teachers were more likely to use small-group or individual instruction.

Drawing on observation data from four mathematics lessons in two first- and fifth-grade classes in 11 Chinese, 10 Japanese, and 12 U.S. elementary schools, Stevenson and Lee (1995) found that Chinese teachers were also more likely to vary their instructional tasks to hold student attention and more likely to teach students to respond to mathematics problems in a rapid manner. Similarly, on the basis of 617 observations from two first- and two fifth-grade classes in 10 Taiwanese, 10 Japanese, and 20 U.S. schools, Perry (2000) found that Chinese teachers, more than their U.S. counterparts, offered increasingly direct and complex explanations to their students as they moved from first grade to fifth grade.

Second, on the basis of the assumption that teachers' mathematics knowledge and its representation are central to effective teaching and student learning (Ball & Bass, 2001; Shulman, 1987), other studies also examined the nature of teachers' mathematics knowledge, conceptual representation, and curriculum materials as a basis for explaining the performance differences. Using interviews with 23 U.S. and 72 Chinese elementary teachers as a source, Ma (1999) found that Chinese elementary teachers perceived mathematics concepts as interconnected and considered student learning to include reasoning, justification, and the use of multiple approaches to finding solutions. In contrast, their U.S. colleagues perceived these concepts as arbitrary collections of facts and rules and saw mathematics learning as following established step-by-step procedures to arrive at solutions. In addition, through case study analysis, researchers (Paine, 1997; Paine & Ma, 1993; Wang & Paine, 2003) found that Chinese teachers' systematic study of centralized mathematics curriculum and regular discussions about the curriculum and teaching with their colleagues in teaching research groups also presumably contributed to Chinese teachers' understanding of mathematics content and its learning. However, because interviews were conducted with only a few teachers from both countries and data were drawn from a limited number of Chinese case studies of elementary teachers, generalization is limited.

Third, several studies were designed to look at teachers' mathematical representation in their classrooms to explain student performance differences in the two countries. On the basis of observations of teaching in one Chinese classroom and one U.S. classroom and interviews with students, parents, and teachers, Yang and Cobb (1995) found that Chinese children were encouraged by their teachers to construct composite, multiunit numerical conceptions; to understand numerical relationship at the tenth level; and to develop and justify their solutions to problems in whole-class instruction. Conversely, U.S. students were encouraged to construct unitary concepts with little explanation or justification, which may have limited their understanding of the base-ten system. By analyzing four Chinese beginning middle school teachers' lessons on triangles and their curriculum materials, Wang (2002) found that these teachers were able to use increasingly sophisticated mathematics problems to engage their students in integrating the current and previously learned concepts and providing justifications for their problem solutions. Students in the study were continually engaged in this manner as these teachers moved the lessons from stages of instruction, to guided practice, and then to independent practice. Again, the potential for generalization is limited because the case studies in this line of research involved only a few elementary and middle school teachers in both countries.

In general, the existing literature indicates that Chinese teachers, when compared with U.S. teachers, were able to use their teaching time more effectively for student learning, to develop better-organized whole-class instruction, and to offer more complex explanations and feedback to their students. They may also have a deeper understanding of mathematics and mathematics learning and be more able to help students connect various mathematics ideas, develop multiple solutions to mathematics problems, and justify their solutions. However, these studies were generally limited to a descriptive level. Direct and statistical relationships between teaching-related factors and student mathematics performance were not clearly established in these studies. Although suggesting a relationship between curriculum, teaching, and overall better Chinese performance, the existing research evidence seems to contradict the finding that Chinese students are not necessarily better performers in solving complex and open-process mathematics problems (Cai, 1995, 2000; Cai & Silver, 1995). These mathematics competencies often require students to develop flexible connections between mathematics concepts and multiple solutions. Although reflected in Chinese teachers' conceptions of mathematics, the learning of mathematics (Ma, 1999), and classroom practice (Wang, 2002; Yang & Cobb, 1995), these connections and problem-solving skills are not clearly evident in Chinese students' performance as measured in the comparative studies.

Therefore, the existing research on teaching-related factors and their influence on student mathematics performance lack substantial support for the presumption that standardized curriculum and relevant teaching—important elements in the rationale for U.S. mathematics education reform—have a positive effect on student performance. Such findings can lead to another conjecture: that teaching-related factors may interact with social and cultural factors that influence students' mathematics performance. This speculation is consistent with the findings of the 2003 comparative study of mathematics performance of countries in the Organisation for Economic Co-operation and Development (OECD). That study reported that the direct influences of schooling factors have little association with students' mathematics performance unless influences of social and cultural factors are taken into consideration (Program for International Student Assessment, 2004). Clearly, more comparative studies are necessary to explore relationships between kinds of teaching-related factors and student performance in various competency areas with substantial attention given to the interactive influences of social–cultural influences.

Influence of Chinese Language-Related Factors

The fact that the Chinese outperform U.S. students even before their exposure to formal schooling (Geary et al., 1993; Geary & Liu, 1996; Ho & Fuson, 1998; Miller & Stigler, 1987) prompted some researchers to explore factors other than formal teaching to explain performance differences. One of these research areas examines the effects of language on thinking and mathematics achievement following the Sapir-Whorf hypothesis that the structure of a language strongly influences or even determines the way its native speakers perceive the world (Sapir, 1949; Whorf, 1956).

Several studies identified the relationship between number naming and the base-ten numeration system in the Chinese language as a contributing factor to Chinese students' better mathematics performance. Miura et al. (1988) taught 20 Korean kindergartners and groups of 24 American, 25 Chinese, 24 Japanese, and 40 Korean students in the beginning months of their first-grade experience that 10 one-unit blocks were equal to 1 ten-unit block. The children were then asked to use 100 one-unit and 10 ten-unit blocks to represent symbolic numbers. The study found that U.S. children relied on collections of one-unit blocks to represent symbolic numbers while using fewer combinations of various unit blocks. In contrast, most Chinese, Japanese, and Korean children were able to construct the symbolic numbers through correct combinations of various unit blocks.

The researchers interpreted this finding as a result of the congruence between base-ten numeration systems and the number-naming systems in the Chinese, Japanese, and Korean languages, which have no parallel in the English language. These findings were further supported in subsequent studies in which French and Swedish students whose languages were not congruent with base-ten representations were added to the study (Miura et al., 1994).

Another area of research on language effects on mathematics performance centers on Chinese linguistic clarity in conveying and portraying mathematical ideas. Some researchers found that when compared with the English language, the better clarity of the Chinese language in conveying mathematical concepts may contribute to better Chinese student understanding of mathematics concepts. In an experimental study, Han and Ginsburg (2001) asked groups of 48 Chinese and 48 U.S. adults to define Chinese and English mathematics words commonly used in middle school curriculum. They then tested three groups of Chinese American eighth graders with similar mathematical abilities as measured by school mathematics examinations: 33 Chinese-only speakers, 29 bilingual speakers of Chinese and English, and 20 English-only speakers. Subsequently, the researchers administered a mathematics test that presented words related to mathematics concepts unfamiliar to the participants in both Chinese and English. The study showed that the Chinese adults tended to agree with each other on the meaning of the Chinese words more than their U.S. peers agreed on the meaning of equivalent English words. The Chinese-only speakers and bilingual speakers of Chinese and English also performed substantially better than the English-only group. On the basis of these findings, the researchers inferred that Chinese language clarity contributed to better student performance in the first two groups.

The last group of studies on language effects focused on the relationship between Chinese character writing and the development of spatial abilities. In examining the possible impact of writing two-dimensional Chinese characters on Chinese students' spatial abilities crucial for geometry learning, Li, Nuttall, and Zhou (1999) compared three groups of college students: 295 native Chinese, 49 Chinese Americans who could write in Chinese, and 195 Chinese Americans who were unable to write in Chinese. On the basis of their performance in completing Piaget's water-level tasks developed to measure the ability to perceive space, the study showed that the native Chinese and Chinese Americans who could write in Chinese performed substantially better than the Chinese Americans who could not write in Chinese. A subsequent study (Li & Nuttall, 2001) used SAT-mathematics and -verbal tests, water-level tasks, and mental rotation tasks to examine 45 Chinese American undergraduates who could write in Chinese and 108 Chinese American undergraduates who could not write in Chinese. The study reported that being able to write Chinese characters was statistically related to higher scores on SAT-mathematics, water-level tasks, and mental rotation tasks but was not related to higher performance on SAT-verbal tests.

It is worth noting that, although these studies of the effects of language on mathematics performance used experimental designs involving comparisons of groups, only a small number of participants from different age groups were involved in each study. Two limitations are obvious in such studies. First, the small sample size limits the potential to generalize the findings. Second, experimental designs often necessitate the identification of predetermined, isolated, conceptualized variables for investigating cause-and-effect relationships, which limits the examination of other possible confounding variables that may potentially influence the identified variables in the study. For example, although these studies of language effects were able to control for the influence of schooling on specific mathematics skills by focusing on children in the early stage of first grade or on Chinese Americans who had relatively little exposure to formal Chinese mathematics teaching and curriculum, none of the studies in this area controlled for the influences of culture, family values, or family processes as possible confounding variables that could influence students' language and relevant mathematics performances.

Nevertheless, the research in this area points to several possible advantages of Chinese language for mathematics performance. For instance, the fact that the Chinese number naming is consistent with a base-ten numbering system may help students do well on tasks relevant to base-ten values, such as counting skills and place-value competence. The clarity of the Chinese language in representing mathematics concept may also contribute to better conceptual understanding, and there may be a close connection between Chinese writing and spatial abilities. These findings seem to confirm the weaker form of the Sapir-Whorf hypothesis that language and culture can influence each other mutually (Sapir, 1949; Whorf, 1956).

However, the assumption that being knowledgeable in Chinese character writing may help a student to develop better spatial thinking seems to conflict with the finding that Chinese students are not necessarily better in visual and graph-related mathematics performance when compared with U.S. students (Brenner et al., 1999; Stevenson, Lee, Chen, & Lummis, 1990). Therefore, additional studies are needed to better control other confounding variables and to use broader populations from various contexts to extend the understanding of language effects on mathematics performance.

Influence of Student Self-Concept and Expectations

Besides attributing the achievement gap to teacher, classroom, and language effects, researchers have examined the relationship between students' self-concepts and expectations for mathematics learning and their mathematics performance. Akin to a humanist perspective on learning that assumes that positive self-concepts lead to higher motivation and thus to positive learning outcomes (Maslow, 1971; Rogers, 1982), several comparative studies have explored the relationship between self-concept and the mathematics performance of students in China and the United States. Contrary to the humanistic theoretical prediction, these studies (Chen & Stevenson, 1995; Stevenson, Chen, & Lee, 1993), which used surveys with large numbers of participants in both countries, found that Chinese students in the first, fifth, and higher grades were less confident than U.S. students about their mathematics learning. Nonetheless, in these studies Chinese students performed substantially better in school mathematics content-based achievement tests. This finding was consistent with a more recent large-scale comparative study conducted by the OECD (Program for International Student Assessment, 2004) in which, among all the participating countries, students from Hong Kong, Japan, and Korea reported the lowest self-concept in mathematics despite being the top-performing countries in mathematics. In contrast, U.S. students in the study who scored lower than the average mathematics performance held the highest self-concept in mathematics among all the participating countries.

Other studies (Eaton & Dembo, 1997; Whang & Hancock, 1994) also suggest that such self-concepts held by Chinese students are not necessarily related directly to formal Chinese schooling processes, because Asian Americans (consisting mostly of Chinese Americans in the reviewed studies) at various grade levels had self-efficacy beliefs about their mathematics learning that were significantly lower than the self-efficacy beliefs of non-Asian groups (mostly Caucasians), despite the superior mathematics performance of Asian American students in school mathematics content-based achievement tests.

Using the social learning theory as a basis (Bandura, 1989), other researchers have explored the influence of student expectations for mathematics learning and the influence of students' extended effort on their mathematics performance. One survey found that, compared with the U.S. norms, 517 Chinese high school students were more likely to choose difficult tasks for themselves (Shen, Sullivan, Igoe, & Shen, 1996). In another survey study, 578 Chinese 11th graders were able to devote more effort and time to their learning than their 578 U.S. counterparts (Fuligni & Stevenson, 1995). In addition, on the basis of surveys with 738 U.S. and Chinese fourth graders who were underperformers in mathematics, Tuss, Zimmer, and Ho (1995) found that Chinese students, when faced with hypothesized success and failure, were more likely than their U.S. counterparts to see the reasons for their mathematics performance as controllable and internal.

Again, Chinese students' higher expectations and more effort in mathematics learning cannot be interpreted simply by the influences of formal schooling processes. Drawing from surveys of 78 Asian and 209 Caucasian American students (Campbell & Connolly, 1984) and surveys of 545 Asian American and 561 Caucasian American students in 4th to 11th grades (Ryckman & Mizokawa, 1988), studies in U.S. contexts also suggest not only that Asian Americans are more likely to attribute their academic success and failure to their own effort, but also that the Asian Americans spend more than twice as much time as their Caucasians peers on studying and research activities. However, in spite of the substantial number of participants in the above studies, this finding was derived without consideration of variations among different Asian American ethnic groups. As shown in another study, substantial differences were found to exist among six ethnic groups of 211 Asian Americans in the assessment of students' causal attributions for success and failure in specific academic subject areas (Mizokawa & Ryckman, 1990).

These studies suggest that Chinese students' lower confidence in mathematics learning may propel them to expect higher mathematics performance, devote more time and effort to mathematics learning, and, consequently, attain higher achievement. In comparison, the higher confidence levels of American students do not help them to excel in mathematics. On the contrary, American students are more likely to believe that ability is more important than effort in determining their mathematics learning. Such findings challenge directly the widespread humanist assumption that increasing students' positive self-concept about mathematics learning will lead directly to higher learning outcomes. Moreover, the findings in this area of research suggest that Chinese students' mathematics learning is not necessarily the consequence of Chinese formal schooling, because the same parallel pattern exists between Asian Americans and Caucasian American students.

Although sustaining a direct statistical relationship between students' expectation for and effort in mathematics learning and students' overall mathematics performance, these findings fail to properly account for difference in performance in specific areas of mathematics as demonstrated in the two countries. For instance, Chinese students' self-reported beliefs about their greater effort in mathematics learning convey little information about how such beliefs are transferred into the types of effort that enable them to excel in symbolic and abstract mathematics thinking but not in concrete and graphic mathematics competencies. Therefore, more refined research needs to be developed if we are to understand *why* and *how* particular groups of students develop certain psychological characteristics that lead them toward typical mathematics competencies.

Influence of Family Values and Processes

In addition, Chinese students' success in mathematics presumably stems in part from family values and processes. Our analysis of the research in that area demonstrated the importance of parental expectations and parental support in the mathematics performance of Chinese students.

Following the social psychological perspective that assumes children's academic achievement to be a direct or indirect result of self-fulfilling prophecy processes that are shaped by the expectations of parents and teachers (Rosenthal, 1974; Rosenthal & Jacobson, 1968), some studies, using surveys and interviews, explored the relationship between parental expectations for their children's mathematics learning and student mathematical competencies. Crystal and Stevenson (1991) found that Chinese parents tended to be more critical of and dissatisfied with their children's mathematics performance than U.S. parents were. When identifying the problems that their children experienced in school mathematics learning, Chinese mothers often considered problems to be related to the use of strategies, whereas U.S. parents interpreted these problems as related to basic calculation and drill-based procedures. Chinese students were more likely to agree with their parents' higher expectations; U.S. children viewed mathematics as a relatively easy subject area and said that they had already met their parents' expectations. These findings were based on the survey results of high school students (Chen, 1991) and first and fifth graders (Stevenson, Lee, Chen, Lummis, et al., 1990) in both countries. In addition, both Chinese and Chinese American mothers, more than their Caucasian American counterparts, were more likely to attribute their children's success in mathematics learning to school-related factors and their low performance to children's lack of effort (Hess, Chang, & McDevitt, 1987). Hess et al. based their conclusions on interviews with mothers of sixth graders about their children's mathematics learning; of these mothers, 47 were Chinese, 51 were Chinese American, and 67 were native-born Caucasian.

Other researchers interpreted mathematics competency differences between the two nations as resulting from different types of parental support for children's mathematics learning. Using the theoretical assumption that parental informal and formal education at home could be important sources for children's academic success (Bernstein, 1971; Dunn, 1981; Young-Loveridge, 1996), Huntsinger et al.'s longitudinal study (2000) followed a group of 40 Chinese Americans and a group of 40 Caucasian American students, along with the parents of both groups, from preschool to fourth grade. Through standardized mathematics tests, parental interviews, and observation of parent-child interactions, the researchers found not only that Chinese American children performed significantly and increasingly better than the Caucasian children in mathematics at all three points of measurements during the 4-year study but also that Chinese American parents devoted more structured time to teaching their children in a more formal and systematic manner. These findings again diverge from the norms of the Western literature on the subject, which assumes that, at earlier ages, an informal learning environment rather than formal teaching leads to children's better academic performance.

In general, the studies relevant to family values and processes suggest that Chinese parents set higher expectations for their children's mathematics achievement, engage their children in working more on mathematics at home, and use formal and systematic instructional approaches at home. Exposure to these family values and processes appears to produce children's synergism with parental expectations and may lead to higher general mathematics achievement. Similar family values and processes were also found in Chinese American families.

However, this line of research does not provide a satisfactory interpretation of the varying mathematics competencies that Chinese students often display when measured against their U.S. peers. For instance, how do these family influences account for the better performance of Chinese students in computation and application of formulas and their weaker performance in open-process problem solving? One plausible explanation is that performance differences in particular areas of mathematics competencies are shaped by particular mathematical cognitive processes among Chinese students rather than by the generally higher expectations and support that Chinese students can access when developing these cognitive processes. Thus, future research needs to explore carefully the types and extent of the support provided to students inside and outside school environments in the two nations.

Conclusion and Discussion

How does the literature about differences between Chinese and U.S. students' mathematics learning inform us about mathematics curriculum standards and professional development in the United States? Our review suggests that the existing literature does not provide enough evidence to support conclusively a direct positive relationship between the implementation of curricular and pedagogical features (curriculum standards, teaching organization, teachers' mathematics knowledge, standards-based teaching practice) and high mathematics performance by students.

First, although Chinese students perform better *in general,* their performance in the areas of mathematics competencies as envisioned by the U.S. curriculum standards is less well understood and, in some cases, is not substantially better than that of their U.S. counterparts.

Second, although a limited number of studies show a positive relationship between students' performance, on the one hand, and curriculum materials, teachers' mathematics knowledge, organization of instruction, and representation of mathematics ideas in Chinese classrooms, on the other hand, these studies do not provide a satisfactory interpretation of the disparities in performance between the Chinese students and their U.S. peers. For example, although Chinese teachers possessed a deeper understanding of mathematical connections and required their students to develop flexible connections among mathematical concepts and to find multiple, divergent solutions to mathematics problems (Ma, 1999), Chinese students were not better than U.S. students at solving complex and open-process mathematics problems (Cai, 1995, 2000; Cai & Silver, 1995).

Third, Chinese students' better *general* mathematics performance as compared with that of U.S. students cannot be attributed solely to the Chinese formal schooling or teaching process. As suggested in our literature review, several non-school-related factors very likely make important contributions to Chinese and Chinese Americans' mathematics performance. These factors may include the nature of Chinese language, students' self-concept and effort, and family values and processes.

However, our review has deepened our understanding of mathematics learning in several ways. First, it reinforces the idea that mathematics learning is a culturally scripted activity whose outcome is a function of interrelated factors and environments (Wang, 2002; Yang & Cobb, 1995). At the same time, it suggests the complexity of such an idea. For example, some factors may appear to be nationally situated, such as teachers' knowledge, formal teaching practice, and curriculum standards as seen in China. Some may be transnational across several countries, such as the congruence between number naming and the base-10 numbering system in Japan, China, and Korea, as compared with the inconsistent number naming systems in the United States, France, and Sweden. Other factors may be cultural without reflecting national boundaries, such as the family values and processes shared by Chinese students and Chinese American students and their parents.

Second, the influence of a culturally scripted network of factors on student mathematics learning may not be additive. Instead, it may be adaptive, like any complex system, and a change in one factor in the network may not necessarily change the total outcome (Stigler & Hiebert, 1999). For instance, it is plausible that the nature of mathematics learning may be influenced by complex functions of parental perception and expectations and schooling effects. That is, knowing that their children lack Chinese formal schooling influences, Chinese American parents may respond by providing more formal learning support, which in turn, may drive Chinese American students to perform better in mathematics even in U.S. schools.

Third, the existing literature does not provide enough evidence to develop a complete picture of the network of factors and its adaptive transformation. To develop this picture, a different conception must be developed to guide comparative studies. It could include reconceptualizing research designs to view mathematics learning as influenced by adaptive rather than additive factors and by interactive rather than isolated variables. Moreover, rather than focusing on comparisons using *general* performances, future studies should examine the effects of influential factors on *specific* areas of mathematics competencies.

On the basis of these understandings, we believe that the following three kinds of research would be especially useful for developing a deeper and more discriminating understanding of how Chinese and U.S. students perform in mathematics and the factors that affect their performance. First, we need comparative studies that target and investigate the specific competency areas envisioned by U.S. reformers and the specific types of cognitive learning and teaching strategies that enhance students' performances in these areas.

Second, we need carefully designed and crafted comparative studies that make controlled and direct comparisons among native Chinese, Chinese American, and other U.S. racial groups at various stages of immigration. Such studies not only will help determine the effects of factors such as teaching, language, motivation, and family processes on mathematics learning but also will contribute to a better understanding of how schooling and nonschooling factors interact with each other in exerting influence on student mathematics learning.

Third, we need more grounded qualitative studies to capture hidden forces that have not necessarily been considered because of the limitations of various theoretical perspectives that have guided past research investigations in conceptualizing and revealing these hidden factors.

Perhaps these kinds of studies will provide greater insight on reforming instruction and furthering educational equality for *all* ethnic minority students. For instance, future studies may deepen our understanding of *all* Asian American students, who are often touted as "the model minority" because of their perceived high measures on achievement tests. Future findings may dispel this positive stereotypical view, which "often overlooks the immense national origins diversity of Asian American ethnic groups; the serious language and social adjustment problems that some Southeast Asian new immigrants encounter in the United States; the great disparities in Asian American verbal and mathematics achievement; the self-concept dilemmas of many higher achieving Asian Americans; the special education needs of individual students; and the high dropout rates among some Asian groups, such as Hmongs, Cambodians, and Vietnamese" (Banks & Banks, 2001, p. 208).

NOTE

We would like to thank Michele Foster, Stafford Hood, Martha Yager and the three anonymous reviewers for their valuable comments and assistance in the preparation of this article. As well, we especially appreciate the insightful feedback provided by William Speer from the University of Nevada, Las Vegas, during the preparation of our earlier draft. A version of this article was presented at the 2005 annual meeting of the American Educational Research Association in Montréal, Canada.

REFERENCES

Apple, M. W. (2001). Markets, standards, teaching, and teacher education. *Journal of Teacher Education, 52*(3), 182–196.

Baker, D. P. (1997). Good news, bad news, and international comparison: Comment on Bracey. *Educational Researcher, 26*(1), 16–17.

Ball, D. L., & Bass, H. (2001). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 83–104). Westport, CT: Ablex Publishing.

Bandura, A. (1989). Self-regulation of motivation and action through internal standards and goals system. In A. Pervin (Ed.), *Goal concepts in personality and social psychology* (pp. 19–85). Hillsdale, NJ: Lawrence Erlbaum.

Banks, J., & Banks, C. (2001). *Multicultural education: Issues and perspectives* (4th ed). New York: John Wiley & Sons.

Beaton, A. E., Martin, M., Mullis, L., Gonzalez, E., Smith, T., & Kelly, D. (1996). *Science achievement in the middle school years: IEA's Third International Mathematics and Science Study (TIMSS).* Chestnut Hill, MA: TIMSS International Study Center, Boston College.

Beaton, A. E., Mullis, L., Martin, M., Gonzalez, E., Kelly, D., & Smith, T. (1996). *Mathematics achievement in the middle school years: IEA's Third International Mathematics and Science Study (TIMSS).* Chestnut Hill, MA: TIMSS International Study Center, Boston College.

Berliner, D. C., & Biddle, B. J. (1996). Standards amidst uncertainty and inequality. *School Administrator, 53*(5), 42–44, 46.

Bernstein, B. (1971). *Class, codes and control: Theoretical studies towards a sociology of language* (Vol. 1). Boston, MA: Routledge & Kegan Paul.

Blair, S. L., & Qian, Z. (1998). Family and Asian students' educational performance: A consideration of diversity. *Journal of Family Issues, 19*(4), 355–374.

Bracey, G. W. (1993). American students hold their own. *Educational Leadership, 50*(5), 65–67.

Bracey, G. W. (1996). International comparisons and the condition of American education. *Educational Researcher, 25*(1), 5–11.

Bracey, G. W. (1997a). The Japanese education system is a failure, say some Japanese. *Phi Delta Kappan, 79*(4), 328–330.

Bracey, G. W. (1997b). Response: Good news, bad news, and international comparisons: Comment on Bracey. *Educational Researcher, 26*(1), 19–26.

Bracey, G. W. (1999). The demise of the Asian math gene. *Phi Delta Kappan, 80*(8), 619–620.

Bracey, G. W. (2000a). The TIMSS "final year" study and report: A critique. *Educational Researcher, 29*(4), 4–10.

Bracey, G. W. (2000b). Trying to understand teaching math for understanding. *Phi Delta Kappan, 81*(6), 473–474.

Brenner, M. E., Herman, S., Ho, H. Z., & Zimmer, J. M. (1999). Cross-national comparison of representational competence. *Journal for Research in Mathematics Education, 30*(5), 541–557.

Brophy, J. (1989). Research on teacher effects: Uses and abuses. *Elementary School Journal, 89*(1), 3–21.

Cai, J. (1995). *Cognitive analysis of U.S. and Chinese students' mathematical performance on tasks involving computation, simple problem solving, and complex problem solving* (Monograph 7, *Journal for Research in Mathematics Education*). Reston, VA: National Council of Teachers of Mathematics.

Cai, J. (1997). Beyond computation and correctness: Contributions of open-ended tasks in examining U.S. and Chinese students' mathematical performance. *Educational Measurement: Issues and Practice, 16*(1), 5–11.

Cai, J. (1998). An investigation of U.S. and Chinese students' mathematical problem posing and problem solving. *Mathematics Education Research Journal, 10*(1), 37–50.

Cai, J. (2000). Mathematical thinking involved in U.S. and Chinese students' solving of process-constrained and process-open problems. *Mathematical Thinking and Learning, 2*(4), 309–340.

Cai, J., & Silver, E. A. (1995). Solution processes and interpretations of solutions in solving a division-with-remainder story problem: Do Chinese and U.S. students have similar difficulties? *Journal for Research in Mathematics Education, 26*(5), 491–496.

Campbell, J. R., & Connolly, C. (1984). *Impact of ethnicity on math and science among the gifted.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Chen, C. (1991, April 18–20). *American, Chinese, and Japanese students' acceptance of their parents' values about academic and social activities.* Paper presented at the biennial meeting of the Society for Research of Child Development, Seattle, WA.

Chen, C., & Stevenson, H. W. (1995). Motivation and mathematics achievement: A comparative study of Asian American, Caucasian-American, and East Asian high school students. *Child Development, 66*(4), 1215–1234.

Cochran-Smith, M., & Lytle, S. (1999). Relationship of knowledge and practice: Teacher learning in communities. *Review of Research in Education, 24,* 249–298.

Cohen, D. K., & Spillane, J. P. (1992). Policy and practice: The relations between governance and instruction. *Review of Research in Education, 18,* 3–49.

Crystal, D. S., & Stevenson, H. W. (1991). Mothers' perceptions of children's problems with mathematics: A cross-national comparison. *Journal of Educational Psychology, 83*(3), 372–376.

Dunn, N. E. (1981). Children's achievement at school-entry as a function of mothers' and fathers' teaching sets. *Elementary School Journal, 81*(4), 245–253.

Eaton, M. J., & Dembo, M. H. (1997). Differences in the motivational beliefs of Asian American and non-Asian students. *Journal of Educational Psychology, 89*(3), 433–440.

Fernandez, C., & Chokshi, S. (2002). A practical guide to translating lesson study for a U.S. setting. *Phi Delta Kappan, 84*(2), 128–134.

Fuligni, A. J., & Stevenson, H. W. (1995). Time use and mathematics achievement among American, Chinese, and Japanese high school students. *Child Development, 66*(3), 830–342.

Geary, D. C., Bow-Thomas, C. C., Fan, L., & Siegler, R. S. (1993). Even before formal instruction, Chinese children outperform American children in mental addition. *Cognitive Development, 8*(4), 517–529.

Geary, D. C., & Liu, F. (1996). Development of arithmetical competencies in Chinese and American children: Influence of age, language, and schooling. *Child Development, 67*(5), 2022–2044.

Gu, W. (1997). *The differences of mathematics achievement between American children and Chinese children.* Unpublished master's thesis, Winona State University, Winona, Minnesota.

Han, Y., & Ginsburg, H. P. (2001). Chinese and English mathematics language: The relation between linguistic clarity and mathematics performance. *Mathematical Thinking and Learning, 3*(2–3), 201–220.

Hess, R. D., Chang, C.-M., & McDevitt, T. M. (1987). Cultural variations in family beliefs about children's performance in mathematics: Comparisons among the People's Republic of China, Chinese-American, and Caucasian-American families. *Journal of Educational Psychology, 79*(2), 179–188.

Hiebert, J., & Stigler, J. W. (2000). A proposal for improving classroom teaching: Lessons from the TIMSS video study. *Elementary School Journal, 101*(1), 3–20.

Ho, C. S. H., & Fuson, K. C. (1998). Children's knowledge of teen quantities as tens and ones: Comparisons of Chinese, British, and American kindergartners. *Journal of Educational Psychology, 90*(3), 536–544.

Holmes Group. (1986). *Tomorrow's teachers.* East Lansing, MI: Author.

Holmes Group. (1990). *Tomorrow's schools.* East Lansing, MI: Author.

Huntsinger, C. S., Jose, P. E., Larson, S. L., Krieg, D. B., & Shaligram, C. (2000). Mathematics, vocabulary, and reading development in Chinese American and European American children over the primary school years. *Journal of Educational Psychology, 92*(4), 745–760.

Interstate New Teachers Assessment and Support Teaching Consortium. (1992). *Model standards for beginning teacher licensing and development: A resource for state dialogue.* Washington, DC: Council of Chief State School Officers.

Lewis, C. C. (2000). *Lesson study: The core of Japanese professional development.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Lewis, C. C., Tsucbida, I., & Coleman, S. (2002). The creation of Japanese and U.S. elementary science textbooks: Different process, different outcomes. In G. DeCoker (Ed.), *National standards and school reform in Japan and the United States* (pp. 46–66). New York: Teachers College Press.

Lewis, C. C., & Tsuchida, I. (1998). A lesson is like a swiftly flowing river: How research lessons improve Japanese education. *American Educator, 22*(4), 12–17, 50–52.

Li, C., & Nuttall, R. (2001). Writing Chinese and mathematics achievement: A study with Chinese-American undergraduates. *Mathematics Education Research Journal, 13*(1), 15–27.

Li, C., Nuttall, R., & Zhao, S. (1999). The effect of writing Chinese characters on success on the water-level task. *Journal of Cross-Cultural Psychology, 30*(1), 91–105.

Linn, M. C., Lewis, C., Tsuchida, I., & Songer, N. B. (2000). Beyond fourth-grade science: Why do U.S. and Japanese students diverge? *Educational Researcher, 29*(3), 4–14.

Ma, L. (1999). *Knowing and teaching elementary mathematics.* Mahwah, NJ: Lawrence Erlbaum.

Maslow, A. H. (1971). *The farther reaches of human nature.* New York: Viking Press.

Mayer, R. E., Sim, V., & Tajika, H. (1995). A comparison of how textbooks teach mathematical problem solving in Japan and the United States. *American Educational Research Journal, 32*(2), 443–460.

Miller, K. F., & Stigler, J. W. (1987). Counting in Chinese: Cultural variation in a basic cognitive skill. *Child Development, 2,* 279–305.

Miura, I. T., Chungsoon, K. C., Chang, C. M., & Okamoto, Y. (1988). Effects of language characteristics on children's cognitive representation of number: Cross-national comparisons. *Child Development, 59*(6), 1445–1450.

Miura, I. T., Okamoto, Y., Kim, C. C., Chang C. M., Steere, M., & Fayol, M. (1994). Comparisons of children's cognitive representation of number: China, France, Japan, Korea, Sweden, and the United States. *International Journal of Behavioral Development, 17*(3), 401–411.

Mizokawa, D. T., & Ryckman, D. B. (1990). Attributions of academic success and failure: A comparison of six Asian-American ethnic groups. *Journal of Cross-Cultural Psychology, 21*(4), 434–451.

National Council for Accreditation of Teacher Education. (1999). *Proposed NCATE 2000 unit standards.* Washington, DC: Author.

National Council for the Social Studies. (1994). *Expectations of excellence: Curriculum standards for social studies.* Washington, DC: Author.

National Council of Teachers of English & International Reading Association. (1996). *Standards for the English language arts.* Urbana, IL: Authors.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Research Council. (1996). *National science education standards.* Washington, DC: National Academy Press.

Paine, L. W. (1997). Chinese teachers as mirrors of reform possibilities. In William K. Cummings & P. G. Altbach (Eds.), *The challenge of Eastern Asian education* (pp. 65–83). Albany: State University of New York Press.

Paine, W. L., & Ma, L. (1993). Teachers working together: A dialogue on organizational and cultural perspectives of Chinese teachers. *International Journal of Educational Research, 19*(8), 667–778.

Perry, M. (2000). Explanations of mathematical concepts in Japanese, Chinese, and U.S. first- and fifth-grade classrooms. *Cognition and Instruction, 18*(2), 181–207.

Program for International Student Assessment. (2004). *Learning for tomorrow's world: First results from PISA 2003* (OECD Publications No. 53799 2004). Paris: Organisation for Economic Co-operation and Development.

Robitaille, D. F., & Garden, R. A. (Eds.). (1989). *The IEA Study of Mathematics II: Contexts and outcomes of school mathematics.* New York: Pergamon Press.

Rogers, C. (1982). *Freedom to learn in the eighties.* Columbus, OH: Merill-Prentice Hall.

Romberg, T. A. (1990). I never promised you first place. *Phi Delta Kappan, 72*(4), 296–303.

Romberg, T. A. (1997). The influence of programs from other countries on the school mathematics reform curricula in the United States. *American Journal of Education, 106*(1), 127–147.

Romberg, T. A. (1999). School mathematics: The impact of international comparisons on national policy. In G. Kaiser, E. Luna, & L. Huntley (Eds.), *International comparison in mathematics education* (pp. 189–199). Philadelphia, PA: Falmer Press.

Rosenthal, R. (1974). *On the social psychology of self-fulfilling prophecy: Further evidence for Pygmalion effects and their mediating mechanism.* New York: MSS Modular Publications.

Rosenthal, R., & Jacobson, I. (1968). *Pygmalion in the classroom: Teacher expectation and pupils' intellectual development.* New York: Holt, Rinehart and Winston.

Ryckman, D. B., & Mizokawa, D. T. (1988, April 5–9). *Causal attributions of academic success and failure: Asian Americans' and White Americans' beliefs about effort and ability.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Sapir, E. (1949). *Culture, language and personality.* Berkeley: University of California Press.

Schmidt, W. H., McKnight, C. C., Cogan, L. S., Jakwerth, P. M., & Houang, R. T. (1999). *Facing the consequences.* Boston: Kluwer Academic Publishers.

Shen, S., Sullivan, H., Igoe, A., & Shen, X. (1996). Self-presentation bias and continuing motivation among Chinese students: A cross-cultural phenomenon. *Journal of Educational Research, 90*(1), 52–56.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Stanley, J. C., Huang, J. F., & Zu, X. M. (1986). SAT-M scores of highly selected students in Shanghai tested when less than 13 years old. *College Board Review* (140), 10–13, 28–29.

Stedman, L. C. (1997a). Deep achievement problem: The case for reform still stands. *Educational Researcher, 26*(1), 27–29.

Stedman, L. C. (1997b). International achievement differences: An assessment of a new perspective. *Educational Researcher, 26*(3), 4–15.
Stevenson, H. W. (1993a). Bracey's broadsides are unfounded. *Educational Leadership, 50*(5), 68.
Stevenson, H. W. (1993b). Why Asian students still outdistance Americans. *Educational Leadership, 50*(5), 63–65.
Stevenson, H. W., Chen, C., & Lee, S. (1993). Motivation and achievement of gifted children in East Asia and the United States. *Journal for the Education of the Gifted, 16*(3), 223–250.
Stevenson, H. W., & Lee, S. (1995). The East Asian version of whole-class teaching. *Educational Policy, 9*(2), 152–168.
Stevenson, H. W., Lee, S.-Y., Chen, C., & Lummis, M. (1990). Mathematics achievement of children in China and the United States. *Child Development, 61*(4), 1053–1066.
Stevenson, H. W., Lee, S.-Y., Chen, C., Lummis, M., Stigler, J., Fan, L., et al. (1990). Mathematics achievement of children in China and the United States. *Child Development, 61*(4), 1053–1066.
Stevenson, H. W., & Stigler, J. W. (1992). *Learning gap.* New York: Summit Books.
Stigler, J. W., Fernandez, C., & Yoshida, M. (1996). Traditions of school mathematics in Japanese and American elementary classrooms. In L. P. Steffe & P. Nesher (Eds.), *Theories of mathematical learning* (pp. 149–175). Mahwah, NJ: Lawrence Erlbaum.
Stigler, J. W., & Hiebert, J. (1999). *Teaching gap.* New York: Free Press.
Stigler, J. W., Lee, S. Y., & Steven, H. W. (1990). *Mathematical knowledge of Japanese, Chinese, and American elementary school children.* Reston, VA: National Council of Teachers of Mathematics.
Stigler, J. W., Lee, S. Y., & Stevenson, H. W. (1987). Mathematics classrooms in Japan, Taiwan, and the United States. *Child Development, 58*(5), 1272–1285.
Stigler, J. W., & Perry, M. (1988). Mathematics learning in Japanese, Chinese, and American classrooms. *New Directions for Child Development, 41,* 41.
Stigler, J. W., & Stevenson, H. W. (1991). How Asian teachers polish each lesson to perfection. *American Educator: The Professional Journal of the American Federation of Teachers, 15*(1), 12–20, 43–47.
Tobin, J. J., Wu, D. Y. H., & Davidson, D. H. (1989). *Preschool in three cultures: Japan, China, and the United States.* New Haven, CT: Yale University Press.
Tsuchida, I., & Lewis, C. C. (2002). How do Japanese and U.S. elementary science books differ? Depth, breadth, and organization of selected physical science units. In G. DeCoker (Ed.), *National standards and school reform in Japan and the United States* (pp. 35–45). New York: Teachers College Press.
Tuss, P., Zimmer, J., & Ho, H. Z. (1995). Causal attributions of underachieving fourth-grade students in China, Japan, and the United States. *Journal of Cross-Cultural Psychology, 26*(4), 408–425.
Uttal, D. H., Lummis, M., & Stevenson, H. W. (1988). Low and high mathematics achievement in Japanese, Chinese, and American elementary-school children. *Developmental Psychology, 24*(3), 335–342.
Wang, J. (2002). *Beginning teaching mathematics in middle schools: Forms and substance of Chinese teachers' instructional discourses.* Paper presented at the annual conference of the Comparative and International Education Society, Orlando, FL.
Wang, J., & Paine, L. W. (2003). Learning to teach with mandated curriculum and public examination of teaching as contexts. *Teaching and Teacher Education, 19*(1), 75–94.
Whang, P. A., & Hancock, G. R. (1994). Motivation and mathematics achievement: Comparisons between Asian-American and non-Asian students. *Contemporary Educational Psychology, 13*(3), 302–222.
Whorf, B. L. (1956). *Language, thought and reality.* London: Chapman and Hall.
Yang, M. T. L., & Cobb, P. (1995). A cross-cultural investigation into the development of place-value concepts of children in Taiwan and the United States. *Educational Studies in Mathematics, 28*(1), 1–33.
Young-Loveridge, J. M. (1996). The number language used by preschool children and their mothers in the context of cooking. *Australian Journal of Early Childhood, 21*(1), 16–20.

AUTHORS

JIAN WANG is an Associate Professor in the Department of Curriculum and Instruction, University of Nevada, Las Vegas, College of Education, 4505 Maryland Parkway, Box 453005, Las Vegas, NV 89154-3005; wangj2@unlv.nevada.edu. His research interests include teacher education, teacher learning, teacher mentoring, and the comparative study of mathematics teaching practice.

EMILY LIN is an Assistant Professor in the Department of Curriculum and Instruction, University of Nevada, Las Vegas, College of Education, 4505 Maryland Parkway, Box 453005, Las Vegas, NV 89154-3005; emily.lin@ccmail.nevada.edu. Her research interests include teacher education reform, teaching practices, and comparative science and mathematics education.

Manuscript received December 13, 2004
Revision received March 27, 2005
Accepted April 9, 2005