Chinese students have excelled in many international assessments of mathematics achievement (e.g. Programme for International Student Assessment [PISA] and the Third International Mathematics and Science Study [TIMSS]), thereby drawing great interest from researchers, educators, and policy makers inside and outside the Chinese community. This chapter draws upon three strands of research (developmental, instructional, and social-psychological) cutting across three different levels (societal/cultural [macro, nation], institutional [meso/micro, family, classroom], and individual [nano]) to examine the ingredients that have shaped the mathematics achievements of Chinese students.

The chapter starts by tracing the early numerical development of Chinese children before considering learning and instruction in Chinese mathematics classrooms. Next, it explores the broader sociocultural contexts in which the Chinese way of learning and teaching mathematics is rooted and supported. Finally, we depict a profile of Chinese students’ achievements in mathematics against these backgrounds. The layers of description can help paint a richer understanding of Chinese students’ mathematics achievement and its contexts.

Before we turn to the specific discussions, it is important to indicate upfront that Chinese students here referred to are the groups of urban students from the mainland China, HKSAR, and Taiwan, as most of the referenced studies in the chapter involved students from Hong Kong, Taipei and several cities of mainland China (e.g. Beijing, Shanghai, Changchun, Guiyun, etc.).

Numerical development of Chinese children in their early years

Studies suggest that Chinese children and children of other countries show differences in mathematics achievement before they receive any formal school education (Ginsburg et al, 2006; Stevenson et al, 1990; Stevenson, Lee, & Stigler, 1987; Starkey & Klein, 2008). Chinese preschoolers outperformed their English-speaking counterparts from the United States on generating cardinal and ordinal number names (Miller, Major, Shu, & Zhang, 2000). They showed better understanding of the base-ten system and fractions, and using tens-complement strategy for early addition (Fuson & Kwon, 1991). Among kindergarteners to third graders solving simple addition problems, Chinese children used verbal counting strategies more often than did US children, who counted on their fingers more often. Decompositions were the primary backup strategy for the Chinese children. In contrast, the American children used finger counting as the backup strategy (Geary, Bow-Thomas, Liu, & Siegler, 1993, 1996).
The better performance by Chinese children in numerical literacy has been attributed to linguistic (Miura et al., 1994) and sociocultural factors (Ho & Fuson, 1998; Miller, Smith, Zhu, & Zhang, 1995; Saxton & Towse, 1998; Towse & Saxton, 1997). There is much greater regularity in Chinese number naming between 11 and 20 and also between 10 and 100. For example, numbers between 11 and 20 are formed by compounding the ‘tens word’ with the ‘unit word’. Thus, the numbers 11 and 12 are spoken as ‘ten-one’ and ‘ten-two’, while 20 is spoken as ‘two-tens’ and 62 is spoken as ‘six-tens-two’. In contrast, English-speaking children have to memorize the relatively awkward numerical names between 1 and 19 as well as all the decade names, ‘twenty’, ‘thirty’, etc. (Miura et al., 1994). The numerical names in English are in a decade structure (twenty, thirty, forty, etc.), instead of the clearer and simpler representations of two-tens, three-tens, four-tens, five-tens. The consistency of the Chinese number naming system with a base-ten system has been hypothesized to assist children in doing well on tasks relevant to base-10 values, such as counting skills and place-value competence.

However, showing that number naming in the Chinese language aided Chinese children’s better performance in mathematics has been difficult, because none of these studies controlled for culture or family processes (e.g. parental expectation, parental assistance, and preschool education) as confounding variables that could also influence children’s mathematics development (Saxton & Towse, 1998; Towse & Saxton, 1997; Wang & Lin, 2005). Saxton and Towse (1998) addressed this issue by comparing the numerical performance of English-speaking and Japanese-speaking children. (The Japanese and Chinese number-naming systems have the same structure.)

In their study, children were shown the relationship between the ones and tens cubes. Then, under the prompt condition, children were shown how to make 2 (from two units) and 13 (from one ten and three units). Under the no-prompt condition, children were shown how to make 2 and 5 (from unit cubes only). In the testing phase, children were asked if they could show how to make some numbers, including two-digit numbers. The results showed that under the no-prompt condition, Japanese children of six and seven years old were more likely than English-speaking children of the same age to give canonical base-10 count responses to represent two-digit numbers, which contain the maximum possible number of ten cubes plus the appropriate numbers of unit cubes. However, under the prompt condition, the two groups of children performed at a comparable level to give the base-10 responses (Saxton & Towse, 1998).

Fuson, Smith, and Lo Cicero (1997) and Othman (2004) also showed that giving explicit instructions to English-speaking and Arabic-speaking children about the base-10 structure of numbers could improve their arithmetic performance (both the English and the Arabic number-naming systems are irregular and incongruent with the base-10 system). These studies showed the importance of adult instruction in children’s learning of mathematics, as such instruction could mediate the role of the linguistic feature of a number naming system.

While US mothers value literacy skills more than mathematics skills in early childhood education, Chinese mothers believe that their children should master both skills before first grade in order to support academic success (Hatano, 1990; Stevenson & Lee, 1990). Kelly (2003) showed that American mothers mostly emphasized reading in preparations for their children’s going to school, while Chinese mothers focused on both reading and mathematics for such preparation. In addition, Chinese parents believe that children’s trajectories in mathematics achievement are already established early in preschool and tend to persist in elementary school; thus, they think that preschool children who lag behind their peers in mathematics performance tend to fall further behind in elementary school. Hence, Asian parents, particularly Chinese parents, put early pressure on their children to learn, and on preschools to teach, the mathematics curricula.

Chinese parents’ expectations affect preschool curriculum and instruction. To meet parental demands, preschool mathematics curricula have absorbed formal mathematics curricula from elementary schools in Hong Kong and in mainland China (Starkey & Klein, 2008; Cheng & Chan, 2005). The mathematics curricula for four- to six-year-old children in many cities, e.g. Hong Kong, Shanghai, Beijing, are similar to those for first- and second-grade students. Many Chinese children, even as young as two to three years old, begin to learn counting, digit recognition, and writing tasks.
At five years old, they are asked to do arithmetic exercises, including addition and subtraction with and without carry-over. Adults, preschool teachers, parents and grandparents help coach children to solve mathematics problems (Cheng, Chan, Li, Ng, & Woo, 2001). (As Chinese have a collectivist culture, grandparents often live near their grandchildren and attend to their care and early education much more than do their Western counterparts [Georgas et al, 2001].) For example, the adults at home and at preschools often teach children to recite 1 to 100 repeatedly. Also, adults generally teach children to do addition and subtraction by counting their fingers. For instance, adults can ask children to compute ‘7 + 5 =’ with the counting-on strategy by putting 7 in their mind, opening five fingers and counting up ‘eight, nine, ten, eleven, twelve’ (Cheng & Chan, 2005). Urban Chinese children who attended regular preschool and kindergarten education usually can count, add, and subtract 0–20 proficiently before entering first grade (Zhang, Li, & Tang, 2004).

While some preschools believe that early childhood education should not include mathematics, others prepare students for primary-school mathematics (Clements, 2001). Chinese society as a whole adopts the latter view, and uses an adult-centered instructional approach to teach children numerical facts and skills. Supporting this approach, emerging evidence from infant research shows that preschool children can naturally acquire and use whole numbers, just as they acquire and use spoken language (Gallistel & Gelman, 1992; Geary, 1994; Ni & Zhou, 2005; Starkey & Klein, 2008).

The operational mathematics curriculum is one early childhood curriculum used in China since the 1900s to introduce mathematics to preschoolers in an accessible manner and to prepare them for primary-school mathematics (Cheng, 2007, 2008). Like Montessori schools, the operational learning curriculum concretizes mathematics (e.g. by using a 10 x 10 grid), but also connects them to their respective mathematics concepts (e.g. cardinal and ordinal numbers, place values, arithmetic operations) and organizes them to highlight their systematic structure (e.g. addition, subtraction, and part–whole structures in a base-10 system). As a result, students can create an image of the logico-mathematical system of concepts and operations, thereby aiding their learning of abstract logico-mathematics in Chinese elementary schools (Cheng, 2007; 2008).

Consider the following example: children are shown four faces and asked to identify attributes that may be used to classify the faces into different groups. These four faces feature three attributes: one face has a hat and three do not; two happy faces and two angry faces; and three circular faces and one square face. Preschool teachers ask their students to observe and analyze the attributes and relationships of the four faces. Then, they guide the students’ use of beads to model the relationships as they solve addition and subtraction problems within this universe of 4 (e.g. 1 + 3 = 4, 2 + 2 = 4, 3 + 1 = 4; 4 – 1 = 3, 4 – 2 = 2, 4 – 3 = 1). Next, the students develop their understanding of part–whole relations for the numbers 2, 3, and 5–10 by doing classification tasks with these numbers on a 10 x 10 grid.

The grid and these part–whole relationships can help preschoolers use composition and decomposition strategies to solve addition and subtraction problems involving larger numbers. For example, consider solving 8 + 7 with the 10-complements (up-over-10s) strategy (8 + 7 = 8 + [2 + 5] = [8 + 2] + 5 = 10 + 5 = 15). First, teachers guide children to focus on the first addend (8 dots) and decide how many extra dots are needed to make up a row of 10 on the grid (in this case, 2 + 8 = 10). Second, teachers ask students to split 7 into 2 dots and a remaining portion of 5 dots (7 = 2 + 5). Third, teachers guide students to add 8 and 2 to create a row of 10 on the grid (8 + 2 = 10). In the fourth step, students add the remaining 5 to the row of 10, yielding 15 (10 + 5 = 15). Then children work independently on addition problems yielding sums greater than 10 (e.g. 5 + 9). This operational approach helps students acquire the skill components necessary for mathematics competence (Cheng, 2008).

As indicated in the above discussions, Chinese preschoolers benefit from higher parental expectations and assistance, linguistic advantages, and supportive preschool mathematics compared to their Western counterparts. As a result, Chinese preschoolers outperform Western preschoolers in many areas of mathematics (Miller, Kelly, & Zhou, 2005; Miller, Major, Shu, & Zhang, 2000), creating an advantage that can continue through their later years of schooling.
Instruction in Chinese mathematics classrooms

The importance of classroom instruction is highlighted by findings of similar IQ-test scores by American and Chinese children, similar numeracy skills of Chinese and American adults, but Chinese children’s higher numeracy test scores (Geary et al, 1996; Stevenson et al, 1985). These observations along with Chinese students’ superior performance on international assessments point to the capacity of mathematics curriculum and instruction to increase the mathematics achievement of Chinese children (Stigler & Hiebert, 1999).

The Chinese mathematics curriculum in the mainland emphasizes two-basics (basic mathematics concepts and basic mathematics skills), and Chinese classroom instruction focuses on refined lectures and repeated practice (Zhang et al, 2004). The two-basics view emphasizes foundational knowledge content and skills over creative thinking process (Leung, 2001; Li & Ni, 2007). Chinese educators argue that repeated practice aids memorization and the greater exposure can help students think about the underlying concepts more deeply (Dhlin & Watkins, 2000; for detailed socio-historical analyses of the origins of these Chinese beliefs, see Wong, 2004; Zhang et al, 2004). Hence, Chinese mathematics curricula have four student goals: 1) fast, accurate manipulation and computation of arithmetic, fractions, polynomials, and algebra; 2) accurate recall of memorized mathematics definitions, formulas, rules, and procedures; 3) understanding of logical categorizations and mathematics propositions; and 4) facile matching of solution patterns to types of problems via transfer (Zhang et al, 2004).

To implement these curricula, teachers present well-prepared lessons that include strong teacher control, coherent instruction, and abstract mathematics (refined lectures; Zhang et al, 2004). To deliver such refined instruction, teachers in Beijing and Taipei spend over six hours each day examining students’ work and preparing lessons with colleagues, far more than do their US counterparts (Stevenson & Stigler, 1992).

Teachers often maintain control by direct teaching to the whole class. Direct teaching helps teachers control the lesson flow to maintain class discipline (especially with forty to sixty students per class in China), while engaging students in the learning activities (Huang & Leung, 2004). As Confucian culture assigns content expertise to teachers, traditional Chinese students are also more receptive to the teacher’s dominant role. Stevenson and Stigler (1992) reported that Chinese teachers led their classes 90 per cent of the time, whereas US teachers did so 47 per cent of the time.

Secondly, the refined lecture should unite teaching content and classroom discourse through coherent connections that guide students toward their learning goal for each lesson (Wong & Murphy, 2004). Chinese teachers’ lesson plans also enhance instructional coherence by emphasizing the relationships among mathematics concepts. For example, some studies, that involved teachers and students from Illinois of the USA and those from Guiyang of mainland China, showed that Chinese teachers helped their students specify the similarities and differences between ratios and fractions to clarify their relationship, whereas American teachers did not (Cai, 2005; Cai & Wong, 2006).

Also, when students make mistakes, Chinese teachers often view them as learning opportunities and have the mathematics mastery to ask leading questions that guide students to correct answers (Stevenson & Stigler, 1992). By so doing, Chinese teachers encourage students who have erred to persevere, understand their mistake, and correct it. In contrast, American mathematics teachers typically have less mathematics knowledge than their Chinese counterparts, often feel uncomfortable with student mistakes, and try to avoid them (Ma, 1999; Stevenson & Stigler, 1992; Wang & Murphy, 2004).

Schleppenbach, Perry, Miller, Sims, and Fang (2007) also compared the coherence of mathematics lessons in seventeen Chinese and fourteen American elementary classrooms by examining the frequency and content of extended discourses. Extended discourses are relatively sustained exchanges that occur when a student gives a correct answer to a question (by another student or by the teacher) and the teacher asks a follow-up question, instead of simply evaluating the student’s answer. Here is an example of extended discourse (Schleppenbach et al, 2007):

Teacher : Is this equation, 2xy = 5, an instance of a linear equation with two unknowns?
Student A: No.
Teacher : Why not?
Student A: The power of each unknown should be one for a linear equation in two unknowns. But for this equation, $2xy$ is one unit and its power is two.

Teacher: The power of this single unit is two; therefore it does not belong to the type of linear equations in two unknowns. Do you agree or disagree?

Student B: Agree.

Teacher: Could you give an example of linear equation in two unknowns?

Student B: $3x + 2y = 25$

Schleppenbach et al (2007) found that extended discourse episodes were longer and occurred more often in Chinese lessons than in American lessons.

Chinese teachers also plan more coherent sequences of lessons, as shown in these four lessons from a Shanghai teacher of the highest ranking (first class) who had taught secondary-school mathematics for twenty years (Lopez-Real, Leung, & Marton, 2004). The step-by-step tasks and activities found in these four lessons help students learn linear equations with two unknowns in a logically progressive way.

In the first lesson, the teacher introduced coordinates and identified a point in the coordinate plane uniquely with an ordered pair $(x, y)$. To emphasize precise notation and procedure, the teacher gave examples, asked students to express the ordered pairs of points on the plane and to compare them (e.g. $[2, 5]$ and $[5, 2]$).

In the second lesson, the teacher briefly reviewed the ideas of the first lesson, then asked students to develop the complementary skill of identifying the locations of ordered pairs on the coordinate plane (e.g. $[1, 2]$). Then he drew a square on a coordinate plane and shifted the square in the different directions. To review, evaluate, and consolidate their understandings through extended discourse, he asked the students to find the new coordinates of each vertex as the square changed its positions.

In the third lesson, the teacher asked how many combinations of $1 stamps and $2 stamps a person can buy with $10. Through trial and error, the students discovered many answers (e.g. four $1 stamps and three $2 stamps; $10 = [4 \times 1] + [3 \times 2]$). The teacher then helped the students represent and solve the problem using an equation with two unknowns (e.g. $x[1] + y[2] = 10$). Next, he asked them to analyze the situation and summarized their answers; the linear equation must contain two unknowns and the power of each unknown is one. Afterwards, the teacher asked what values of $x$ and $y$ would satisfy $x + 2y = 10$, ignoring the stamp context and focusing only on the equation itself. After trying many examples, the students figured out that there are infinite solutions to the equation. The teacher then generalized the rule that any linear equation with two unknowns has an infinite number of solutions.

By opening the fourth lesson as follows, the teacher highlighted general relationships and abstractions to further the students’ learning:

In the previous lessons we’ve learned about the … concepts of linear equations in two unknowns and … the coordinate plane. We know that after setting up a coordinate plane, the points in the plane can be represented by pairs of ordered numbers … So is there any connection between the two concepts? Let’s use the equation $2x – y = 3$ as an example for investigation’


These well-designed and coherent mathematics lessons reduced ambiguity and confusion, aiding students as they progressed toward their challenging learning goals of memorization and understanding of mathematics concepts and skills (Dhlin & Watkins, 2000; Wong, 2004).

Related to instructional coherence, Chinese teachers value and use more abstraction to generalize mathematics relationships in their instruction compared to American teachers who value concrete representations more (Correa, Perry, Sims, Miller, & Fang, 2008). Specifically, Chinese and American middle-school teachers differed in their use of concrete representation, prediction of student strategies, and assessment of student strategies (Cai, 2005; Cai & Lester, 2005). Chinese teachers exclusively used concrete representations to mediate students’ understanding of the main mathematics concept in the lesson (e.g. diagram of four cups with different amounts of water to help students compute and understand the concept of arithmetic mean). In contrast, American teachers used concrete
representations to generate data (e.g., students’ heights and arm lengths as data to find their mean height and arm lengths). Furthermore, Chinese teachers were more likely to predict algebraic strategies for their students while American teachers were more likely to predict drawing or guess-and-check strategies for their students. When students used drawing strategies or estimates that yielded correct answers, American teachers scored them higher than Chinese teachers did, as the latter viewed these strategies as less generalizable.

Thus, the approach of the two-basics curriculum and the refined lecture with repeated practice may contribute to more effective Chinese mathematics instruction. The two-basics curriculum might focus students on the key mathematics concepts, skills, categorizations, and flexible applications to problems. Meanwhile, the refined lecture with repeated practice instruction, serving the two-basics curriculum well, might facilitate teachers’ classroom management, increase lesson coherence, and help students generalize mathematics relationships in a step-by-step way. Together, these factors might help Chinese students learn more mathematics than their American counterparts.

Cultural contexts of Chinese students’ mathematics achievement

As shown clearly in the previous discussion, teaching and learning are always a cultural act. The Chinese way of teaching and learning mathematics is rooted in and supported by its cultural-social contexts (see also McBride-Chang, Lin, Fong, & Shu; Kember & Watkins; Hau & Ho, this volume). Researchers have observed that Chinese Americans have outperformed other Asian-Americans and Caucasian-American students in mathematics (Huntsinger, Jose, Larson, Balsink, & Shalingram, 2000), even when these Chinese-Americans were not exposed to formal Chinese schooling. Asian-Europeans also outperformed the native Europeans (Sirin, 2005). These results show that school factors alone do not fully explain achievement differences between Chinese and non-Chinese students. So we next consider more general, social-cultural factors.

Grounded in government exams, collectivist beliefs, and economic rewards, Chinese people (especially parents, schools, and teachers) have traditionally supported students’ high academic achievement. The Keju civil service exam system from 606 to 1905 not only selected China’s government officials but also gave proportional financial rewards, prestige, power, and fame to their extended family, thereby powering collectivist beliefs, values and norms (Suen & Yu, 2006). Unlike Europeans, Chinese people believe that education drives economic success, not negotiation of higher salaries via stronger labor unions (Addison & Schnabel, 2003; Reitz & Verman, 2004). In Hong Kong’s education-rewarding wage system, a high-school teacher earns a manual worker’s lifetime wages in fifteen years while a professor earns it within five years (McLelland, 1991). As a result, Chinese parents, schools, and teachers strongly support students’ academic achievement, especially in mathematics, which opens a door to many professions (Wise, Steel, & MacDonald, 1979).

Chinese parents support their children’s mathematics learning through high expectations, educational resources, and homework assistance. Unlike American parents, Chinese parents view effort as more important than ability for learning mathematics (Stigler, Lee, & Stevenson, 1990). Thus, Chinese parents encourage their children to study diligently and expect them to excel (Hau & Salili, 1996). Chinese parents further enhance their children’s academic motivation by wielding their collectivist beliefs, for example, by reminding them that their success or failure affects their entire family’s reputation (Chiu & Ho, 2006). As a result, Chinese parents showed higher expectations for their children, expressed less satisfaction, and were more likely to recognize their children’s learning problems compared to American mothers (Stevenson et al, 1990).

Chinese parents also invest heavily in their children’s education (e.g., buying books, tutoring children themselves, etc.) to motivate them and raise their academic achievement (Lam, Ho, & Wong, 2002). Within a given family budget, buying proportionately more educational resources reinforces family commitment to children’s learning, implicitly suggesting further social rewards and incentives for higher achievement (Chiu & Ho, 2006). Extra educational resources also give children more
learning opportunities on which they can capitalize to improve their academic achievement (Chiu, 2007). Chinese-American parents also spent more time with their children and used more formal teaching methods than European-American parents (Huntsinger et al, 2000). Chinese parents were also more likely than American counterparts to monitor their children’s homework or help them directly (Stevenson et al, 1990). As greater parental homework assistance does not necessarily yield higher student mathematics achievement, however, the benefit might be more motivational than instructional (Chiu & Ho, 2006).

Prodded by parents’ and society’s high expectations, schools in Chinese societies use challenging curricula, require certified teachers, support group teaching preparation, and share the knowledge of expert teachers. Schools in collectivist Chinese societies implement these high expectations through a national mathematics curriculum and standardized textbooks, whose difficulty typically exceeds that of their American counterparts’ diverse curricula and textbooks (Geary et al, 1996; Leung, 1995; Mayer, 1986; Stigler et al, 1987). To teach these challenging curricula, most teachers in Chinese schools are certified, like those in most East-Asian countries (Akiba, LeTendre, & Scribner, 2007; Chiu & Khoo, 2005; OECD, 2003).

Furthermore, teachers often work together and share their knowledge. Group teaching preparation is common in urban schools of mainland China (Ni & Li, 2009). Teachers work together to help individual teachers understand the teacher manuals, the student textbooks, the curriculum standards, and teaching methods that are believed to be effective. The Ministry of Education officially approves student textbooks and teacher manuals (schools can use only approved textbooks), endorsing them as effective mathematics teaching (J.-H. Li, 2004). In addition, education administrative agencies direct good teachers (e.g. first-class teachers) to demonstrate their classroom teaching to their colleagues inside and outside their school districts for other teachers to learn and improve their teaching.

As a result, Chinese teachers’ lesson plans for a given teaching unit resembled one another’s (including similar learning goals, worked-out examples, homework problems, and presentation structures). In contrast, the lesson plans of American teachers varied substantially, even for teachers in the same school (Cai, 2005; Cai & Wong, 2006). A highly centralized educational system within a collectivist culture (as in mainland China and Hong Kong) aids organizational and administrative efficiency by quickly disseminating socially and culturally favored teaching methods. As Stevenson and Stigler (1992, p. 198) put it:

The techniques used by Chinese and Japanese teachers are not new to the teaching profession nor are they foreign or exotic. In fact, they are ones often recommended by American educators. What the Chinese and Japanese examples demonstrated so compellingly is when widely and consistently implemented, such practice can produce extraordinary outcomes.

Taken together, family, school, and teachers’ high expectations and support of students tend to raise students’ standards, increase their motivation, enhance their learning behaviors, and raise their mathematics achievement (Geary et al, 1996). The combination of collective family expectations, challenging mathematics curriculum, and complex lesson activities helps students appreciate the difficult mathematics they must master to perform well on national, university entrance exams (Davey, Lian, & Higgins, 2007; Wong, 1993). Combined with their collective belief that their academic success or failure affects their family, Chinese students are motivated to study diligently while lacking confidence and fearing failure (Lam et al, 2002; Whang & Hancock, 1994).

Western educators generally believe that intrinsic motivations (e.g. getting students interested in mathematics) would benefit students to learn, while extrinsic motivations would only cause anxiety in students and hinder learning. In contrast, Chinese students believe that extrinsic motivations aid learning, in addition to intrinsic motivation. These extrinsic motivators (e.g. examinations, expectations, and social status) are deeply rooted in the Chinese culture (J. Li, 2003). Driven by these intrinsic and extrinsic motivations, Chinese students are much more likely to do their homework and also spend more time doing homework than either American or Japanese students (Chen & Stevenson,
Their greater motivation and efforts typically yield higher mathematics performance (Beaton et al., 1996; Chiu & Zeng, 2008).

A portrait of Chinese students' mathematics achievements

Taught in a curriculum emphasizing the two-basics and classroom instruction using a highly directive approach, Chinese students’ mathematics performance showed certain characteristics (Cai & Cifarelli, 2004): Chinese students had strong computation skills and solved routine mathematics problems well but had more difficulties with non-routine problems. An example of a routine question is: 'The actual distance between Maple County and Orange County is 54 km. On the map, the distance between the two counties is 3 cm. The distance between Orange County and Lake County is 12 cm. What is the actual distance between Lake County and Orange County? Show how you found your answer.'

An example of a non-routine problem with multiple answers is: ‘Ming and Fang, high-school students, take part-time jobs. Ming earns 15 RMB per day and Fang earns 10 RMB per day. How many days do Ming and Fang have to work respectively so that they will earn the same amount of money? Show how you found your answer.’

Chinese students performed better than American students on the routine problems but not on the non-routine problems (Cai, 2000). Results of the international comparative studies also suggested that Chinese students’ performance when they solved practical, non-routine mathematics problems was not as good as when they answered routine, math test items (Fan & Zhu, 2004).

Chinese students demonstrated high levels of accuracy and efficiency in dealing with word problems in mathematics. In particular, they were more likely than American students to use abstract and generalized strategies to solve the problems. Both American and Chinese students were more likely to solve mathematics problems correctly when they used symbolic representations (Cai & Hwang, 2002; Cai & Lester, 2005; Fan, & Zhu, 2004), suggesting that the preference for abstract strategies helped Chinese students to solve the problem. As noted earlier, Chinese teachers urge their students to express mathematics ideas formally and precisely (Lopez-Real et al, 2004). In contrast, American teachers let their students express mathematics ideas informally (e.g. in their own words: see Cai, 2005; Schleppenbach et al, 2007).

Chinese students also used more conventional strategies than did American students to solve mathematics problems, resulting in highly accurate solutions (Cai, 2000; Wang & Lin, 2005). When asked if each girl or each boy gets more pizza when 7 girls share 2 pizzas equally and 3 boys share 1 pizza equally, the Chinese and American sixth-grade students used eight different strategies to solve the problem. For those who used appropriate strategies, over 90 per cent of the Chinese students used the conventional strategy of comparing the fractions 1/3 with 2/7. However, only about 20 per cent of the US students used this strategy. The majority of the American students used less precise, non-conventional strategies (e.g. 3 girls share a pizza and the other 4 girls share a pizza; each of the latter 4 girls gets less pizza than do each of the 3 boys).

Chinese students were able to generate more solutions than did American students, suggesting the effectiveness of the two-basics curriculum and coherent classroom instruction. When American seventh and eighth graders and Chinese sixth graders were asked to generate three different solutions to the above pizza problem, about 40 per cent of the Chinese students generated more than one solution, but only about 20 per cent of the American students did so. Again, Chinese students preferred abstract representations such as: 7/2 = 3.5 and 3/1 = 3; therefore 3.5 girls share 1 pizza and 3 boys share 1 pizza; so fewer boys share the same-size pizza and each one gets more pizza (Cai & Lester, 2005).

Chinese students appeared less willing to take risks to solve mathematics problems. Given a problem that they did not know how to solve, Chinese students were more likely to leave it blank, but American students often wrote down something anyway (Cai & Cifarelli, 2004). It is unclear why Chinese students did not want to guess an answer to the problem to which they did not have a solution. One speculation might be related to the beliefs of teachers about the nature of mathematics.
Wong and his associates (N.-Y. Wong, Lam, K. Wong, Ma, & Han, 2002) reported that Chinese teachers tended to view mathematics as a fixed set of rules and algorithms discovered by great mathematicians. They believed that to learn mathematics is to master the rules and algorithms and to match them to types of problems to be solved. The conceptions of mathematics might lead to an oversight by the teachers on the aspects of mathematics thinking as induction, imagination and hypothesis testing in their mathematics teaching (Wong, 2002; Wong et al, 2002). This in turn might affect students’ views about mathematics (e.g. getting right answers is the most important thing in learning mathematics) and consequently their approaches to learning the subject (e.g. less willing to take risks and to be creative).

It is an empirical question whether or not the conceptions of mathematics would make Chinese teachers more likely to discourage guessing at answers than are non-Chinese teachers, e.g. American teachers in classroom teaching and assessment. An additional reason might be that Chinese students were instructed by their teachers that it is dishonest for one to pretend to know when one does not know, which is a Confucian doctrine and also an aspect of moral education in schools of mainland China. In connection to this, the teachers might deduct marks for wrong answers to deter students from guessing in testing.

Despite the small samples involved, these observations suggest some limitations to Chinese students’ mathematics achievement. One question is whether this is a trade-off for Chinese students’ high performance on basic mathematics concepts and computations (especially with directive teachers and high student–teacher ratios). While directive teaching and coherent instruction in Chinese mathematics classrooms probably reduced ambiguity for students, it might also have constrained students from taking risks or being creative. The observations also serve as a caution for the importance of carefully interpreting Chinese and non-Chinese students’ mathematics achievement in international studies.

It is worth mentioning that the new mathematics curriculum of mainland China, which was implemented in 2006 (Ministry of Education, 2002), has taken note of the limitations to Chinese students’ achievement in mathematics. The curriculum is attempting to have a more balanced curricular and instructional treatment to nurture in Chinese students the skills of mathematical computations, the skills of carrying out mathematical explanations and communications, and interest in and disposition towards mathematics (Ni, Li, Cai, & Hau, 2008).

**Fig. 10.1** Constituents of Chinese students’ mathematics achievement.
In 2008, Professor Shing-Tung Yau of Harvard University, a Fields Medalist for mathematics, established the Yau Shing-Tung mathematics scholarship for secondary-school students in mainland China. In an interview, he was asked why he set up the scholarship since Chinese students have done so well in international assessments and mathematics Olympiads. Professor Yau explained that the scholarship can encourage Chinese students to pose meaningful mathematics questions and to work independently on a posed problem for a substantial period of time (such as a few months, rather than the few hours which is required by the Olympiads). Professor Yau’s vision for Chinese mathematics education points to new horizons for Chinese students.

In sum, the Chinese students’ mathematics achievement, for its strengths and weaknesses, is a result of the developmental, instructional, and social/cultural contexts that they experience (summarized in Figure 10.1). Moreover, the relationship of the contributing factors is viewed to be adaptive rather than additive (Stigler & Hiebert, 1999), as the factors function as parts of an ecological system. After all, Chinese students’ mathematics achievement is a product of their enculturation.

References


