Chapter 6
East Asian Students' Mathematics Performance: A Values-Based Macroeducation Perspective

Wee Tiong Seah and Ting-Ying Wang

Contents

Abstract Attempts at importing and/or adapting pedagogical practices of more successful (mathematics) education systems have not produced desired sustainable and meaningful changes. In this chapter, research publications based on the analyses of country-level data were reviewed in order to identify the values which underlie

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mathematics pedagogical practices in high-performing East Asian jurisdictions. Twelve values were identified, namely, *achievement, effort/perseverance, long-term orientation, product, mastery, not self-concept, class size, student behavior, school climate, school size, grade repetition, and valuing the teaching profession.* These values can be organized along student, institutional, and societal levels. Intervening values and risk factors are also identified. It is recommended that future research investigate the role of religious values, as well as the interaction between (mathematics) learning values of migrant students and those of host countries.

Keywords Achievement · Confucian heritage culture · East Asia · Effort · Long-term orientation · Microeducation · PISA · TIMSS · Values in mathematics education

Introduction

East Asian students' high mathematics performances in international assessment exercises such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) have been sustained from their beginnings more than two decades ago. That a consistent achievement has been maintained across the various East Asian economies despite periodical local curriculum reforms, economic downturns (e.g., the 2008 Global Financial Crisis) and pandemics (e.g., 2003 SARS and 2010s dengue fever) suggest that factors accounting for such performance extend beyond individual students' cognitive, affective, and conative readiness (Pang & Seah, 2020), as well as teaching approaches (Boylan, 2017). Even though cultural factors such as the Confucian heritage culture (CHC) have been offered as an explanatory reason (see e.g., Elliott et al., 2019), it is not clear how cultural differences within this region (Zhang et al., 2016) and Westernization influences might have redefined local cultures in which Confucian teachings interact with more contemporary cultural values.

Such an understanding is important for all countries, as human capital plays an increasingly important role in bringing about economic productivity and growth in current times (OECD, 2010). While the intention is not—and should not be—one of promoting or exporting particular forms of culture to mathematics education systems around the world, this chapter will help us identify values underlying students' mathematics achievement. The assumption here is that these values will find expression in different forms across diverse cultural settings which are the school mathematics classrooms.

This chapter begins with the setting of the context, in terms of the notions of East Asia, Confucian heritage cultures, as well as PISA and TIMSS. We introduce the two concepts which guided our review process, that is, macroeducation and values. Next, we present the values which had been found in the 34 publications reviewed to underlie practices promoting East Asian students' achievement in mathematics. The chapter ends with two recommendations for future research.

Context

East Asia

With our use of the term "East Asia" in this chapter, we do not refer to the geographic division of an area in the Asian continent but to the cultural demarcation as used by Leung et al. (2006) in the 13th ICME Study Conference. In this chapter, we regard these seven jurisdictions as being East Asian, namely, Hong Kong, Japan, Korea, Macau, Shanghai, Singapore, and Taiwan. These East Asian jurisdictions broadly share the same Confucian/Chinese culture/tradition despite their different political, economic, and educational systems (Biggs, 1996; Leung, 2001), and they have consistently been occupying all the top spots in PISA and TIMSS exercises (see Tables 6.1, 6.2, 6.3, and 6.4). It should be noted, however, that there is no one agreed notion of what these jurisdictions are. Leung (2017), for example, stated that East Asian "countries" refer to the systems of Hong Kong, Japan, Korea, Singapore, and Taiwan (p. 204). When Jerrim (2015) was researching PISA 2012 data, he referred to a set of six high-performing East Asian countries, made up of China and the five jurisdictions that Leung (2017) would use a few years later. More recently, Lee and Lee (2021), in their analysis of PISA 2018 data, regarded East Asia as being composed of the six jurisdictions above, plus Macao, based on their world-leading performance scores.

As the title suggests, this chapter is concerned with East Asian students. East Asian students are students of East Asian descent, which means that they do not necessarily need to be attending school in any East Asian jurisdiction. Taking a leaf from Jerrim's (2015) criteria in his research study with "East Asian children" (p. 310) in the PISA 2012 sample, an East Asian student in this current review chapter is regarded as a school student who has at least one of their parents born in any one of seven jurisdictions, namely, Hong Kong, Japan, Korea, Macau, Shanghai, Singapore, and Taiwan.

Confucian-Related Historical Background

The seven East Asian jurisdictions identified above are commonly regarded as CHCs (Leung, 2006). Common societal impressions of education in CHCs include learning practices which facilitate academic success, such as student effort, repeated practice, rote learning (i.e., memorization based on repetition), examination-oriented pedagogy, and teacher-controlled classrooms (Thomas, 2006). These surface phenomena are in fact rooted in beliefs that a good education promises successful future and that through effort everyone can achieve attainment (Leung, 2014). In addition, children in CHC societies are taught to respect and obey their parents and teachers without challenging their authority. Although teachers and parents encourage or even expect students to put in a great amount of effort into their learning, they invest a lot of resources (e.g., time, money, etc.) to help students get academic success (Hu et al., 2018). Yet, due to a mix of colonial history, globalized economy, and/or migration, there have been Western influences on most if not all of the CHCs, albeit to different

Table 6.1 Overview of seven East Asian education systems

Jurisdiction	Educational system format	Students go into different tracks at the end of . . .	High-stakes national examinations for entry to . . .	Career-based versus position-based for teacher jobs	Preservice teachers are normally chosen from . . .
Hong Kong	Primary: 6 years Junior secondary: 3 Senior secondary: 3	10th grade	Tertiary education	Hybrid	Average performers of age group
Japan	Primary: 6 Lower secondary: 3 Upper secondary: 3	10th grade	Upper secondary; tertiary education	Career-based	Above average of age group
Korea	Elementary: 6 Middle: 3 High: 3	10th grade	Tertiary education	Career-based	Best and top performers of age group
Macau	Primary: 6 Junior secondary: 3 Senior secondary: 3	10th grade	Tertiary education	Career-based	Best and top performers of age group
Shanghai	Primary: 5 Junior secondary: 4 Senior secondary: 3	10th grade	Upper secondary; tertiary education	Career-based	Best and top performers of age group
Singapore	Primary: 6 Secondary: 4~5 Preuniversity: 2~3	6th grade	Secondary; preuniversity tertiary education	Career-based	Top 20% of age group
Taiwan	Primary: 6 Lower secondary: 3 Senior high: 3	10th grade	Senior high; tertiary education	Career-based	Above average of age group

Table 6.2 Top five performing jurisdictions in the TIMSS Grade 4 cycles

TIMSS cycle	First	Second	Third	Fourth	Fifth
2003	Singapore	Hong Kong	Japan	Taiwan	Belgium[a]
2007	Hong Kong	Singapore	Taiwan	Japan	Kazakhstan[a]
2011	Singapore	Korea	Hong Kong	Taiwan	Japan
2015	Singapore	Hong Kong	Korea	Taiwan	Japan
2019	Singapore	Hong Kong	Korea	Taiwan	Japan

[a]There was no other participating East Asian jurisdiction

Table 6.3 Top five performing jurisdictions in the TIMSS Grade 8 cycles

TIMSS cycle	First	Second	Third	Fourth	Fifth
2003	Singapore	Korea	Hong Kong	Taiwan	Japan
2007	Taiwan	Korea	Singapore	Hong Kong	Japan
2011	Korea	Singapore	Taiwan	Hong Kong	Japan
2015	Singapore	Hong Kong	Taiwan	Hong Kong	Japan
2019	Singapore	Taiwan	Korea	Japan	Hong Kong

Table 6.4 Top five performing jurisdictions in the PISA cycles

PISA cycle	First	Second	Third	Fourth	Fifth
2000	Japan	Korea	New Zealand	Finland	Australia
2003	Hong Kong	Finland	Korea	The Netherlands	Liechtenstein
2006	Taiwan	Finland	Hong Kong	Korea	The Netherlands
2009	Shanghai	Singapore	Hong Kong	Korea	Taiwan
2012	Shanghai	Singapore	Hong Kong	Taiwan	Korea
2015	Singapore	Hong Kong	Macau	Taiwan	Japan
2018	China (B-S-J-G)	Singapore	Macau	Hong Kong	Taiwan

degrees. For example, Singapore's society appears to be relatively more Westernized than the other CHCs. This can be attributed to its historical role as a British trading port for both Asian merchants and their Western counterparts since the 1800s, its ongoing identity as a global transportation hub, and its ongoing reliance on migration to provide the human capital it requires. The same may also be said of Hong Kong, Macau, Shanghai, and Taiwan.

Japan and Korea were culturally and politically influenced by China for a long time in their histories, resulting in the spread of Confucian ideas to these two jurisdictions (Marginson, 2010). Confucianism was first introduced to Korea in the fourth century, and Confucian ideas and Chinese history have been taught in the Korean National Academy since then. The introduction of Confucian texts and teachings into Japan took place later, in the mid-sixth century. These played a critical role in the development of ethical philosophy, social harmony, and education in Japan over the next few centuries. Although present-day Japan may appear to be very modernized, Confucian and Chinese values still have an impact on Japanese practices in daily life and education (Levi, 2013).

Even though Confucian thoughts might have been extremely influential in shaping the cultures of all the East Asian jurisdictions in this chapter, less discussed and less researched are other schools of thought, such as Buddhism and Daoism which also have followings across most of the seven East Asian jurisdictions, and which also have had an impact on mathematics education outcomes in one way or another (Wong et al., 2012).

Wong et al. (2012) observed that "although Chinese students learn mathematics under a Western educational model, they are learning with a Chinese mentality of examination orientation. All the Chinese cultural values such as social achievement orientation, diligence, attributing success to effort and collectivism come into play" (p. 17). Given the cultural emphasis on the importance of high-stakes examinations in Korea and Singapore, for example, it appears that the above applies not just to Chinese cultures but more broadly across the East Asian jurisdictions as well.

What East Asian Mathematics Education Systems Look Like

Shared values among the East Asian cultures have meant that there are broad similarities within their mathematics classrooms. Of course, culturally specific differences inevitably exist, arising from differences in political systems, different dominant religions (if any), colonial status, etc. In Table 6.1, parameters which can provide an overview of the implementation of mathematics education (Ingvarson et al., 2013) are populated with information specific to the East Asian education systems. It shows the existence of high-stakes national examinations in these East Asian jurisdictions, as well as students studying in the same tracks until 10th grade in most jurisdictions. The table also reflects the status of the teaching profession in these jurisdictions, in which teachers are often held in high regard in many ways.

We present below an account of a typical Taiwanese lower secondary school day. Although it is by no means representative of school mathematics learning across the seven East Asian jurisdictions—a valid generalization is impossible to achieve, anyway—this account should provide readers who are not yet familiar with any of the seven East Asian (mathematics) education systems a glimpse into students' experiences in these nations.

Dun-Dun Wu, an 8th grade student, gets out of bed at 6.50 a.m. and arrives at her school at 7.25 a.m. by bus for a 7-period school day. She rushes into her homeroom, since the morning self-study period starts at 7.30 a.m. and her mathematics teacher, Miss Lin, plans to use this time to give the class a mathematics quiz today. Dun-Dun and her classmates are in the same class from the 7th to the 9th grade, and a homeroom is assigned to them for this whole year. They move to a different classroom only when the subjects require a special instrument or space, such as chemistry or physical education. Miss Lin is also the designated teacher of Dun-Dun's class. The designated teachers of classes are usually those who teach the subjects assessed in the national entrance examinations to the senior high school. Miss Lin usually arrives at the classroom before 7.30 a.m. to check all 27 students' presence and wander through the whole classroom to see whether everyone is studying during the morning self-study period.

The first class is mathematics. In the 10-min break before the first class starting at 08.10 a.m., Dun-Dun, as the student assistant for the subject mathematics goes to the 8th grade teacher's office to take the mathematics exercise books which Miss Lin has already graded back to the classroom and delivers them to each classmate. Dun-Dun listens attentively to Miss Lin's lecture.

She considers Miss Lin to be a good teacher, because Miss Lin is so knowledgeable in mathematics to solve all the challenging problems and is capable of explaining mathematics concepts and procedures very clearly. During the 45-minute class time, in addition to lecturing on the chalkboard and questioning, Miss Lin also provides time to students to do one or two practice exercises after they have seen her demonstrate how to solve sample questions. Occasionally, Miss Lin uses manipulatives or technological instruments.

After the self-study period and four classes in the morning, Dun-Dun looks forward to lunch and the midday rest. Today's school lunch has already been delivered to the classroom at 11.50 a.m. and Miss Lin has come into the classroom to have lunch with the students. Although Dun-Dun is tired and hungry, she accompanies the class leader to the 8th grade teacher's office to take the parent-teacher contact booklets back to the classroom. Miss Lin has reviewed all the booklets and written the things she would like to discuss with the parents in some students' booklets. When everyone gets their booklet back, they record the homework assigned by the teachers of various subjects and grades of quizzes today. Some students feel nervous because their parents could possibly be unsatisfied for the grades they get and would blame them before signing the booklets. The worst situation would be to phone Miss Lin to discuss their academic performances.

As an 8th grader, Dun-Dun's school day ends at 4 p.m. She knows that she will be dismissed one hour later in the next academic year because the 9th graders should spend an extra period in school every day preparing for the national entrance examination to senior high school. The pressure on students to get good grades in this examination is so intense for the students, the teachers, the school, and the parents, that the school requires 9th graders to attend extra classes on weekends during the semesters, and for 3–6 weeks and 1–2 weeks during summer and winter vacations, respectively. Dun-Dun does not directly go home today since she attends a three-hour after-school mathematics class at a tutoring institution this semester. She and her parents both agree that she has to put more effort into mathematics learning because the results of the entrance exam will determine the senior high school that she can attend and the subject of mathematics is greatly emphasized in the examinations.

The TIMSS and PISA International Comparative Assessments

Since the late 1990s, there have been at least two international mathematics assessment exercises held regularly which have attracted the participation of many countries and consequently, much media attention around the world. This section focuses on the two best-known ones, namely, TIMSS and PISA.

Since the 1960s, TIMSS has been a project of the International Association for the Evaluation of Educational Achievement (IEA). It evolved from the First International Mathematics Study, which was held in the 1960s. The Second International Mathematics Study was held in the 1980s and the Third International Mathematics Study in 1995. According to Leung (2018), it was probably the results of the 1995 assessment cycle, when East Asian jurisdictions led the field and "beat" countries such as Germany, Hungary, and the USA, that a TIMSS-Repeat was carried out in 1999. The five East Asian jurisdictions, namely, Hong Kong, Japan, Korea, Singapore, and Taiwan, produced the best results in TIMSS-Repeat. Since then, possibly as a response to the media attention and to political attention attached to the results, IEA has been conducting subsequent cycles every 4 years, with the last cycle taking place in 2019. Given that Grade 4 and 8 students are surveyed in each cycle, the 4-year cycle has meant that TIMSS data from successive cycles take on some longitudinal characteristics.

As shown in Tables 6.2 and 6.3, the top five places in each cycle have been occupied by East Asian jurisdictions, except for the first two cycles in 2003 and 2007 when there were only four East Asian participants for the Grade 4 component. Equally importantly, this achievement has not been maintained at the expense of the lower performers within the respective East Asian jurisdictions. For example, in TIMSS 2019, 96% of Grade 4 students in Hong Kong, Singapore, and Taiwan—and 95% of Grade 4 students in Japan and Korea—achieved at least the intermediate level of the international benchmark, while the international median was 71%. No more than 5% of students in the top five performing jurisdictions, all of which are East Asian, were performing at low or below low levels.

The other international assessment exercise which attracts much attention from different quarters of society around the world has been the three-yearly PISA, which was launched in 2000 by the Organization for Economic Cooperation and Development (OECD). As shown in Table 6.4, only two East Asian jurisdictions took part in the first PISA, and they emerged as the top two. Since 2009, the top five performing jurisdictions have all been East Asian.

Over the years, both PISA and TIMSS results have not only been widely reported in popular media but governments have also paid much attention to them. Curriculum reforms have also been guided by the latest results (Jerrim & Choi, 2014). In fact, Scardino (2008) referred to these two assessment exercises as the "Olympics of Education." In Australia, for instance, the National Assessment Program includes PISA and TIMSS as contributing components to the overall picture of school education across the nation (Australian National Assessment Program, 2016).

Even though both PISA and TIMSS have a mean of 500 and standard deviation of 100, scores are not directly comparable across the assessments, and the same may be said of rank positions. Research studies which make use of both PISA and TIMSS data (e.g., Brown et al., 2007; Jerrim & Choi, 2014) would often transform the test scores into international *z*-scores, normalizing the scores at the student level with a mean of 0 and a standard deviation of 1.

An important difference between these two international comparative assessments is the range of mathematical abilities being assessed. Whereas TIMSS primarily measures students' mathematical knowledge and skills, PISA items assess students' functional ability with these knowledge and skills in terms of how well they can apply them in real-life problems (Jerrim & Choi, 2014). To illustrate this difference, we can draw on Wu's (2011) comparison of PISA 2003 and TIMSS 2003 (Grade 8) released items as they were attempted by students in three East Asian jurisdictions (i.e., Hong Kong, Korea, and Taiwan) and three Western jurisdictions (i.e., Australia, England, and the USA). Her analysis showed that almost half of the TIMSS items were not deemed likely to be included in PISA tests. These items were typically context-free and content-rich items involving formal mathematics which students study in their mathematics classes. The PISA items, on the other hand, emphasized real-life mathematics and required students to bring their knowledge and experience from outside the classroom. It was also found that the PISA items often restricted mathematics to lower-level content and therefore did not reflect the mathematics topics typically taught in schools to 15-year-old students.

Given the stellar performance of students from the seven East Asian jurisdictions, and given the often-heard comment that these students have been overemphasizing rote learning (i.e., memorization based on repetition) and drills, and thus threatening students' capacity to apply what they know in authentic, everyday mathematical situations, it might be expected that they would perform well in TIMSS but not in PISA. Yet, the same East Asian jurisdictions have dominated the performance rankings across both PISA and TIMSS. In fact, the correlation between PISA 2009 and TIMSS 2011 (8th grade) mean test scores for 28 jurisdictions (including East Asian and Western ones) has been a strong 0.88 (Jerrim & Choi, 2014). It needs to be noted, however, that though the East Asian countries outperformed their Western counterparts, the East Asian countries performed relatively better in TIMSS than in PISA, while the Western countries performed relatively better in PISA than in TIMSS (Wu, 2011).

Not all jurisdictions take part in both PISA and TIMSS. For example, 79 jurisdictions participated in PISA 2018 and 64 participated in TIMSS 2019, with only 53 participating in both. Also, for either PISA or TIMSS, the participating jurisdictions differ from cycle to cycle. Among the seven East Asian jurisdictions to which we refer in this chapter, all of them took part in PISA 2018, occupying the top seven positions by performance among the 79 jurisdictions. However, only five of these seven—the exceptions being China and Macao—took part in TIMSS 2019. Among Western jurisdictions, Canada, Germany, Russia, and the USA participated in both PISA 2018 and TIMSS 2019. England took part in PISA 2018, but the entire UK participated in TIMSS a year later. Also, high performers such as Estonia and Switzerland had presence in PISA 2018, but neither of them took part in TIMSS 2019.

In terms of sampling, "each of these resources collects nationally representative data . . . . They also have similar sample designs, with schools firstly selected as the primary sampling unit and then either one or two classes (TIMSS) or 35 pupils (PISA) randomly chosen to participate (from within each school)" (Jerrim & Choi, 2014, p. 352). Sampling-related issues have sometimes been cited as a reason for lower-than-expected performance. For example, according to Guglielmi and Brekke

(2018), a popular argument in the USA used to be that the relatively lower mean achievement scores of American students were due to a disproportionately high number of low socioeconomically disadvantaged students, compared to other jurisdictions. And yet, when the two researchers analyzed the PISA 2012 data by SES quartiles, they found that “the U.S. trailed the top performers (Hong Kong SAR, Japan, Korea, Macau, Shanghai, and Taiwan) at all SES quartiles, and the bottom SES quartile in two of these countries/economies (Shanghai and Hong Kong) outperformed the top quartile in the U.S” (p. 684).

Guiding Concepts

Following the outlining of the context in the last section, this section examines two concepts which have been used to frame this review chapter. The concept of macroeducation reveals our approach to understanding East Asian students’ performance in mathematics learning. Second, the concept of values and valuing in mathematics education will be introduced, to explain why it has been used to make sense of the thinking, the emotions, and the actions adopted by the East Asian students and also of the environment in which they live and learn.

Macroeducation

East Asian students’ sustained performance and achievement is examined in this chapter from a macroeducational perspective. Just like the term “macroeconomics” relates to the performance of economies as a whole, macroeducation is interested in the functioning and performance of school education at the jurisdiction level. Adopting the macroeducational perspective means that we will be interacting with such aspects of mathematics education systems as sociohistorical culture, government policies, school environment, and performance on international comparative assessments.

With this perspective, culture is considered at a broader level, that is, going beyond such considerations as school culture and classroom culture. We include national, socioethnic, and historical cultures. The findings of the latest machine learning approach that had been utilized to analyze the PISA 2018 scores of 590,102 students in 77 jurisdictions highlight the usefulness of adopting this wider perspective (Lee & Lee, 2021). When the top 15 variables of a model constructed which best predicted all the students’ scores were compared with the top 15 variables of another model which predicted the score difference between an average East Asian student and the global average score, some student factors (e.g., SES status and eudaemonia) were replaced by school and societal level variables. These included duration of early childhood education, proportion of youth not in education, employment or training, as well as population density, of R&D researchers. Researching mathematics education at the jurisdiction level not only facilitates generalization of results but it also opens up possibilities of examining the research problems in novel ways, thus uncovering hitherto unidentified new knowledge and understandings.

This is not in any way diminishing the significance of less macro aspects of mathematics education. Although mathematics teacher practice, say, is important in defining and maintaining a particularly enabling environment for effective mathematics learning, such exemplary professional cultures reside at the classroom (or school) level and may not explain how an entire nation of students perform so well. Although it may be particularly powerful in facilitating effective learning for a group of students (and deserves to be documented and celebrated), we also need to develop knowledge and understanding of how mathematics is taught and learnt well by students at the jurisdiction level.

Values in (Mathematics) Education

The second concept with which we frame our review exercise arose from our concern that decades of learning from high-performing countries often have not been usefully employed toward improving education performance in many nations, despite the amount of resources and commitment which have gone into initiatives and policies. We have often heard comments that practices which have worked in a high-performing mathematics education system have not worked in another culture. This leads us to examine the notion of pedagogical practices.

Practices alone do not automatically lead to desired outcomes. Take, for example, the example of "class size" which is often offered by stakeholders as a factor affecting performance (or lack of). Yet, "class size itself does not influence academic achievement. Reducing class sizes improves academic outcomes only insofar as teachers with smaller classes manage to reach their students more effectively" (Guglielmi & Brekke, 2018, p. 685).

Also, the same practice means different things in different cultures. For example, Pan et al. (2022) reported that the practice of students helping their (mathematics) teachers with classroom chores was a source of pride and accomplishment for elementary school students in Chengdu, China, while it was more likely interpreted in Australia as nothing but physical work/duties and inconvenience.

The stand we take, then, is that practices and actions are guided by underlying values and generate more productive learning from high-performing countries through the values perspective. The value-belief-norm (VBN) theory (Stern et al., 1999) describes this relationship between values and norms very well. In the area of school education, Singapore's "values, skills and knowledge (V3SK) model" (NIE, 2009) exemplifies how teacher practices can be viewed as being based around the values embraced by teachers themselves.

Values are convictions that guide behavior (Halstead & Taylor, 2000). That is, they underlie student behavior and influence performance and achievement by exerting a degree of motivation, a feature of values acknowledged by DeBellis and Goldin (2006). All in all, these conceptions are also aligned with Hannula's (2012), comment that values are "closely related to motivation" (p. 144) and the conceptualization that cognition, emotions, and motivation together make up the "explanatory factors of behavior" (p. 144).

In the context of mathematics education, following the pioneering work of Bishop (1988, 1996), "valuing is defined as an individual's embracing of convictions in mathematics pedagogy which are of importance and worth personally. It shapes the individual's willpower to embody the convictions in the choice of actions, contributing to the individual's thriveability in ethical mathematics pedagogy" (Seah, 2019, p. 107).

What Counts as Data

A search in the Scopus database was conducted in late 2021 with the following search string:

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( math* AND "East Asia*" AND value* ) OR
( math* AND "Singapore*" AND value* ) OR
( math* AND "Hong Kong" AND value* ) OR
( math* AND "Taiwan*" AND value* ) OR
( math* AND "Korea*" AND value* ) OR
( math* AND "Japan*" AND value* ) OR
( math* AND "Macau" AND value* ) OR
( math* AND "Shanghai*" AND value* ) ) AND
( LIMIT-TO ( SUBJAREA , "SOCI" ) ) AND
( LIMIT-TO ( LANGUAGE , "English" ).
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This resulted in 361 publications.

A screening process was conducted with the database entries of these 361 publications to remove those which were not related to mathematics education (research). This includes titles such as "the influence of teacup shape on the cognitive perception of tea, and the sustainability value of the aesthetic and practical design of a teacup" (Yang et al., 2019). The next pass removed irrelevant mathematics educational research publications such as "opportunities for learning: the use of variation to analyse examples of a paradigm shift in teaching primary mathematics in England" (Al-Murani et al., 2019). The third pass facilitated the removal of repeat publications reporting on the same research studies.

The full texts of the 178 remaining publications were read in full to identify those which satisfy the following criteria:

- The use of the term "value" (and its related forms) was academic and specific.
- Data had been collected and analyzed at the macroeducation level.
- Topics were concerned with East Asian students' mathematics performance, whether these were students living and schooling in Hong Kong, Japan, Korea, Macau, Shanghai, Singapore, and/or Taiwan, or they were (children of) migrants from these seven jurisdictions.

For example, publications such as Rohaeti (2016) were excluded at this stage of the screening process because they violated the first two criteria above. The reference to Japanese values in the Rohaeti (2016) article was not specific to the review here, and the sample size of 167 student participants did not represent macroeducational level data.

An example of a study satisfying the third criterion above was one conducted by John Jerrim using the Australian data for PISA 2012 (Jerrim, 2015). He identified and analyzed subgroups within the national dataset, each consisting of students who were born in Australia, but with at least one parent who was born overseas. In this context, the "high-performing East-Asia" group would have parents who were born in any one of six of the seven jurisdictions covered in this chapter—that is, China, Hong Kong, Japan, Korea, Singapore, and Taiwan. If these high-performing East Asian students studying in Australian schools were to represent Australia, Australia would have a score of 605, which would have ranked the country second best in the world, below Shanghai and above Singapore! Equally significantly, although Australia's scores were slipping from 2003 to 2012, the scores of the high-performing East Asian students in the Australian sample continued to climb across each cycle in the same 9-year period. "Thus, despite being born and raised in a Western country with an 'average' performing education system, Australian children of East-Asian descent obtain test scores consistent with countries at the top of the PISA rankings" (Jerrim, 2015, p. 322).

Ultimately, a total of 34 publications were retained for this literature review.

The nature of the datasets also meant that we could not conduct a quantitative meta-analysis of the relevant research publications. For example, Ker (2016) and Sandoval-Hernández and Białowolski (2016) drew their data from the same assessment, that is, TIMSS 2011, and these two datasets intersected at both student level variables (e.g., weekly time spent on mathematics homework) and school level variables (e.g., school emphasis on academic success). Any quantitative meta-analysis conducted on these two overlapping datasets would have led to double counting of these data.

For each research publication identified and chosen for review, both authors analyzed the text separately for values which might explain why East Asian students seem to have learnt mathematics so effectively. The guiding question which helped us through the text analysis process was: what is being regarded as important here which has contributed to student achievement? Take, for example, the following block of text:

> Specification 5 adds to the model time spent studying outside of school. This includes both the total amount of time, and the activities on which this time is spent (e.g. homework, private tuition, etc.). The second-generation East Asian parameter estimate declines by approximately 25% – from 0.406 standard deviations (41 PISA points) to 0.290 (29 PISA points). This is consistent with the view that out-of-school tuition (or what it proxies, such as family commitment to their children's education) makes an important contribution to East Asian children's success in PISA. (Jerrim, 2015, p. 326)

On the surface, it may appear that "out-of-school time spent studying" or even "tuition" would be the aspects of mathematics learning which were being valued by the East Asian students and/or their parents. However, we regard these as instrumental values which serve what Tiberius (2018) called "ultimate values," that is, the core values which are deeply internalized within members of a cultural group. To identify the ultimate values, we adopted the "five whys technique" (Serrat, 2017), in which we kept asking "why?" to the values which progressively emerged one after another, until no underlying value was viable for the most recent iteration. So, for "tuition," we would ask "why tuition?", and an underlying value might be *practice*, for example (though it might well be *achievement* in another culture). Then we would ask ourselves, "why practice?", and we might then identify the cultural valuing of *efficiency*, say, at the next level of instrumental valuing. If we could provide an answer to "why efficiency?", the iterative process would continue with the successive instrumental values which "emerged." Otherwise, we would identify *efficiency* as the ultimate value underlying *tuition*. That both researchers of this review exercise are of East Asian cultural background (i.e., from Singapore and Taiwan) has been crucial to establishing the validity and reliability of this review exercise. Even though the approach adopted is called the "five whys technique," our analysis process was not constrained by any maximum number of successive "why" questions posed, and certainly, not five. Instead, we stopped asking the "why" question when both of us agreed that the value at hand was already a core, ultimate value, to which there would be no underlying value.

Some macroeducation-level research on East Asian students' achievements has identified socioeconomic indicators which correlated with mathematics scores. However, we are interested in whether or not gross domestic product (GDP) or R&D researcher density correlates with mathematics scores and whether that actually provides us with causal information with which school improvement policies may be made. Just because a country focuses on lifting its GDP through economic restructuring, for example, does not mean that its students will perform better in mathematics examinations. Rather, these socioeconomic indicators may be symptomatic of changes in practices which result in changes in student performance, and these changes in practices are governed by changes in what are being valued at the individual or larger levels.

Furthermore, findings related to socioeconomic indicators from different studies have been conflicting. Although Hu et al.'s (2018) hierarchical linear models suggested that the GDP per capita of PISA-participating countries did not significantly affect their student mathematics achievements, the studies of Lo (2003) and Chang (2021) revealed that the PPP of TIMSS participating countries correlated with their students' mathematics achievements.

Another kind of conflicting messages can be seen in Jerrim and Choi's (2014) analysis of PISA and TIMSS data from the early 2000s, which indicated that "despite similar levels of GDP per capita, public expenditure on education and school enrolment rates, educational outcomes towards the end of secondary school (as measured by PISA test scores) are significantly lower in England [when compared to Hong Kong, Japan, Singapore and Taiwan]" (p. 5).

Values Associated with Student Achievement

Serrat's (2017) elaboration of a "five whys technique" allowed us to identify ultimate values which underlie East Asian students' achievement in school mathematics. In so doing, we now attribute these students' performance and achievement to a smaller set of core, ultimate values. Thus, as we will see below, cultural practices such as parental aspirations, parental involvement, examinations, and out-of-school tuition might be common in—or even characteristic of—East Asian school mathematics. We regard these as reflecting the cultural valuing of academic *achievement*. As such, it was this value which explained the East Asian students' stellar achievement in TIMSS and PISA cycles, rather than simply any or some of the cultural practices listed above (which served to "feed" into the valuing of *achievement*).

For any other mathematics education system trying to understand how it can "learn from the East-Asian students," this means that they can consider how the (ultimate) values might be espoused in culturally relevant but different ways to support more effective mathematics learning. In so doing, these systems need not simply adopt practices which might be evident in the East Asian education systems. After all, any of these practices is an embodiment of a value that is locally meaningful, so the mere reproduction of it in a mathematics classroom elsewhere is likely to generate different interpretations and effect since the underlying value is interpreted differently.

Our review of the macroeducation academic literature has led us to propose that the following values were evident in the context of East Asian students' mathematics learning and explained the students' performance and achievement in the subject: *achievement*, *effort*, *long-term orientation*, and *product*. They are valued at different cultural levels, as reflected in the discussions in the rest of this section. There has also been a valuing of particular mathematics teaching approaches. Intervening values have also been documented in the literature reviewed. There is also evidence suggesting that values which worked for East Asian students may have an opposite effect for students elsewhere, reminding us of the cultural nature of values and valuing in the context of mathematics teaching and learning.

Cultural Valuing of Academic *Achievement*

In East Asia, academic achievement serves as a critical filter to competitive entries to schools and opportunities in employment. Indeed, in the eyes of many (East) Asian families, the main aim of studying is to gain entry to "good" schools, which would highly likely guarantee a good job as well as the possibility of a brilliant and successful future (Huang & Yore, 2003). This is as true in the East Asian jurisdictions themselves, as it is in East Asian migrant student communities elsewhere (Guglielmi & Brekke, 2018; Jerrim, 2015). Given the importance of mathematics in school curricula around the world, it is easy to understand how this cultural valuing has an impact on mathematics learning and helps to explain the consequential mathematics achievement.

East Asian parents tend to have high aspirations for their children's performance at school. Guglielmi and Brekke's (2018) analysis of PISA 2012 data showed that parental aspirations play a very significant role on students' mathematics performance, through their impact on the children's aspirations. They called it a "context invariant predictor," since

> not only do students from East Asian countries regularly outperform their international peers in cross-national assessment studies, but they continue to do so after moving away from their native countries, despite the difficulties often associated with migration (e.g., language problems, changes in educational systems). This suggests that they are able to bring with them some personal assets that continue to promote math achievement despite a great deal of contextual change. (p. 685)

These parental aspirations are passed on to students via parents' inherent authority on their children's education, which is in turn facilitated by the Confucian heritage culture that is prevalent in the East Asian jurisdictions. Traditionally, children are expected to listen to and obey their parents, while parents control and protect their children to ensure that the high expectations are facilitated by parental involvement. Over 30 years ago, Stevenson et al. (1990) compared children's academic performances and parental expectations and found these were correlated (Huang & Yore, 2003; Leung, 2014). Chinese and Japanese parents involved themselves more in their children's education than American parents and were concerned with their academic achievement to a higher degree. Similarly, Li et al. (2021) also found that parental support predicts achievement for both East Asian and Western students, but also that this relationship was stronger among East Asian communities.

Although the interaction between East Asian parents and their children might have changed from the traditional and conservative styles to more democratic and children-centered manners in recent times, parents still convey to their children their valuing of *education*, academic *achievement*, and *success.* To this end, parental accumulation and protection of a large amount of family money and resources to facilitate the realization of these values are still dominant (Huang & Yore, 2003; Leung, 2014).

In this quest for academic achievement, assessments such as examinations (see Table 6.1) have become crucial means of gauging success. As such, students, parents, and teachers devote much effort into preparing children for these events. The importance placed on mathematics scores in high-stakes tertiary entry examinations, and the inclusion of mathematics in international comparative assessments, such as TIMSS and PISA, have only reinforced in East Asian students the significance of excelling in mathematics at school. Traditionally, too, foundational knowledge, including basic facts, principles, and procedures, appears to be much emphasized in examinations in East Asian jurisdictions (Leung, 2001; Pratt et al., 1999). This might further explain why East Asian students have been performing better in TIMSS than in PISA (Wu, 2011).

The prevalence of out-of-school tuition programs in East Asian societies reflects the valuing of academic *achievement* as well. This expression of valuing is so strong that the tuition industry has also been thriving in Western societies that have sizeable populations of East Asian migrants. Jerrim (2015) reminded readers of "the view that out-of-school tuition (or what it proxies, such as family commitment to their children's education) makes an important contribution to East-Asian children's success in PISA" (p. 326), referring not just to students in East Asia but also to their peers whose parents had migrated out of East Asia.

Cultural Valuing of *Effort* and *Perseverance*

The East Asian culture's valuing of *effort* and *perseverance* also contributes to mathematics achievement. In Lee and Lee's (2021) analysis of 590,102 students' data from PISA 2018, for example, students' mathematics learning time emerged as the fourth most important predictor of student achievement, and this reflects student valuing of *effort*. Famous Chinese sayings such as "progress in studies comes from diligence and is retarded by indolence" (業精於勤荒於嬉) and "diligence is the means by which one makes up for one's dullness" (勤能補拙) reflect the Chinese cultural emphasis on these two values, for example. In the literature reviewed, the Chinese students in Li's (2002) study had attributed their success in learning to diligence and perseverance. These students believed that one should study hard regardless of the obstacles that were in the way, and they would feel shame and guilt whenever they experienced lack of desire to learn. Jerrim's (2015) analysis of East Asian migrant students in Australia also arrived at a similar finding, that even for second-generation East Asian migrant children,

> [their] parents' ability to instil a hard work ethic in their offspring, and a belief that they can succeed if they try hard enough, does indeed make an important contribution to their high PISA test scores. (Jerrim, 2015, p. 327)

Students' appropriate use of ICT for leisure—that is, not too little and not too much time spent on it—has been found in an analysis of PISA 2018 data to be associated with East Asian student achievement. To us, this too is a reflection of students' valuing of *effort* in their (mathematics) learning experience.

Cultural Valuing of *Long-Term Orientation*

Traditionally, the pleasure in (mathematics) learning in East Asian cultures is derived from putting in substantial effort, overcoming many obstacles, achieving a deep understanding of the school subject, and attaining a successful future (Leung, 2001). As the Chinese saying goes, "ten years of study may go unnoticed, but fame in an instant will be known by the world" (十年寒窗無人問, 一舉成名天下知). This notion of what constitutes learning pleasure is different from many (mathematics) education systems elsewhere, which might even describe enjoyment in terms of immediate joy or short-term happiness.

This valuing in the East Asian jurisdictions might be called *long-term orientation* (Hofstede & Bond, 1988). It relates to investing in future reward, in contrast to *short-term orientation* which is about pursuing present gains.

Hu et al. (2018) identified the values of *long-/short-term orientation* as a factor for students' mathematics achievement, which led them to conclude that "national cultural values were important factors explaining student mathematics achievement" (p. 517).

Embracing the *long-term orientation* of mathematics also acknowledges the importance of the school subject for future life. Although this valuing is enabling for East Asian students, it has been found to be a risk factor among the USA students, something leading to lower achievement. This was evident in Kim and Choi's (2021) analysis of 15,580 Korean and the USA eighth-graders' mathematics performance in TIMSS 2015, based on students' responses to six statements (e.g., "I need to do well in mathematics to get the job I want," and "I need mathematics to learn other school subjects") which were brought together to produce a "valuing math" index.

Pedagogical Valuing of *Product*

Leung (2001) argued that, in comparison to their Western counterparts, academics and students in the East Asian cultures traditionally emphasize the *product* view of the nature of mathematics, regarding mathematics as "a body of knowledge with distinctive knowledge structure" (p. 39), rather than the *process* view, which regards mathematics as "a distinctive way or process of dealing with particular aspects of reality" (p. 39). Reflecting this perspective, mathematics teaching in East Asia is often planned for students to grasp the body of knowledge from teachers, and teachers are viewed as instructors or explainers passing on knowledge directly, rather than facilitators promoting knowledge attainment less directly or indirectly (Bryan et al., 2007; Ernest, 1989). Even in current times, despite the influence of Western educational philosophies, East Asians still endorse teaching approaches in which teachers offer detailed illustration of the body of mathematics knowledge more than those involving students' engaging in active work to problem-solve and to learn (Hsieh et al., 2017; Wang & Hsieh, 2017).

This valuing of *product* reflects the demands of the mathematics curriculum, the critical role of mathematics in high-stakes examinations, and the importance of academic achievement (Leung, 2006). Furthermore, this is also pertinent to the traditional image of teachers in CHCs, which is one of being experts or learned figures in the subject matter (Leung, 2005). Teachers are expected to be "scholar teachers," and they are respected in turn due to this, since they can and should fulfill the expectation of conveying the body of knowledge to students correctly and successfully. In so doing, a sustainable cycle operates in the East Asian mathematics education systems, in which students are taught by competent teachers and become competent in mathematics, and from among them, even more competent ones join the teaching force to become competent teachers (Leung, 2006; Schmidt et al., 2012).

Cultural Valuing of *Mastery*

In Lee and Lee's (2021) analysis of PISA 2018 data, East Asian students' valuing of *mastery* was identified as one of the top 15 predictors of mathematics achievement. The potential issue with designing mathematics teaching guided by this value is that it takes on different meanings in the West and in East Asia. It is originally a Western idea, having been proposed by Benjamin Bloom in the 1960s to refer to ensuring a learner fully understands a topic, supported by formative assessment, before progressing to the next topic. The UK's National Centre for Excellence in the Teaching of Mathematics (NCETM, 2022) expresses a similar definition of mastery in the words "mastering maths means pupils acquiring a deep, long-term, secure and adaptable understanding of the subject."

However, when mastery was introduced to the East Asian education systems, it was adapted, such that in Shanghai

> it also includes notions such as the fact there are high expectations for all students, all students go through the curriculum at the same pace with differentiation in terms of the understanding of 'deep content', constant practice and evaluation of what has been learned, and the use of precise questioning in lessons. It differs from western mastery in particular due to its emphasis on 'whole-class interactive teaching'. (Probert, 2021, p. 4)

The different ways in which *mastery* has been understood and valued in East Asia and in the West somewhat reflect the former's valuing of *collectivism*, and the latter's valuing of *individualism* at the societal level. It brings into question if the potential failure of England's "Teaching for Mastery" program, which began in 2014, might be rooted in this differential understanding of *mastery* among teachers in participating schools.

Societal-Level Intervening Values

Guided by the values construct as discussed in this chapter of the *Handbook*, this review of macroeducation-level research literature has interpreted East Asian students' achievement in mathematics as a function of culturally based values. Earlier in this review, we have shown how values present as a more meaningful predictor of student achievement than family, school, or classroom practices. Yet, it was also apparent in several research studies (e.g., Li et al., 2021; Xu et al., 2021; Zhu & Leung, 2011) that the embracing of the same values in different cultures has had different impacts on achievement outcomes. Why has this been the case?

An example is in Xu et al.'s (2021) analysis of PISA 2000 results of 24,388 students from two East Asian jurisdictions (Hong Kong and Korea) and four Western ones (Australia, New Zealand, Scotland, and the USA), in which the students' valuing of *perseverance* affected achievement outcomes differently. Although the association was positive for both the East Asian and Western cultures, it was stronger in the former. Students' self-regulated learning strategy use and motivation constructs were found to be mediating factors, reflecting corresponding convictions which were valued differently by the East Asian and Western students.

Earlier, Zhu and Leung (2011) analyzed more than 46,000 TIMSS 2000 eighth-grade results from five East Asian jurisdictions (Hong Kong, Japan, Korea, Singapore, and Taiwan) and four Western ones (Australia, England, the Netherlands, and the USA). Although forms of both intrinsic and extrinsic motivation were observed positively to affect achievement additively, the effects on the Western cultures were weaker and were in fact negative when considering productivity-oriented motivation (a form of extrinsic motivation) alone.

The explanation offered by Zhu and Leung (2011) was that

> East Asians believe that human beings need some "push" in learning, and therefore, providing an optimal level of pressure could well direct students' energy and attention to study. In contrast, Westerners see human beings in a more positive way; they believe that it is enough to arouse students' interest for them to be initiated to learn. (p. 12)

This association of extrinsic and intrinsic motivations with East Asian and Western cultures was made more explicitly by Li et al. (2021), based on their analysis of 1,254,237 students' performance in mathematics, reading, and science in PISA 2009, 2012, and 2015. They suggested that the different cultural valuing of *individualism/collectivism* played an intervening role in regulating how passion predicted achievement relatively strongly in Western cultures, but the association was much weaker (though still positive) with the relatively collectivistic East Asian cultures. That is to say, although passion represents an independent mode of motivation which is aligned with individualistic cultures, and which thus promotes achievement, passion can run into conflict with relatively collectivistic cultures, thus weakening the association between passion and achievement.

It does appear from these studies that even though one or more of the values that one embraces may be promoting performance and achievement in one's own culture, the extent to which the same value(s) would have the same effect in another culture can be "interrupted" by other values which are also embraced by that culture. This is a reminder that values do not exist singly, and that in any particular culture, there can be other values in the value system which might be more internalized and which thus appear to "intervene" in having an impact on achievement.

Institutional Valuing Regarding School Organization

The values identified in the previous few subsections related to what students embraced in their mathematics learning experiences. Institution-level valuing of certain factors associated with how schools organize their (mathematics) lessons has also been found to be key to understanding why East Asian students have achieved so well. Lee and Lee (2021) applied the machine-learning approach on to the 590,102 sets of PISA 2018 student data, identifying the top 15 features governing East Asian students' achievement. Among these were five school-level features, corresponding to the valuing of *class size, student behavior, school climate, school size,* and *grade repetition*.

Societal Valuing of the *Teaching Profession*

The values discussed so far have been at the student or institutional level. Another category of values associated with East Asian students' achievement which became evident during the literature search may be considered to be societal in nature. In so doing, the three categories match those which evolved from Lee and Lee's (2021) machine learning analysis of the PISA 2018 data.

An example—that is, the societal valuing of the *teaching profession*—can be found in Jerrim and Choi's (2014) analysis of the results of students in four East Asian jurisdictions, specifically Hong Kong, Japan, Singapore, and Taiwan, and in England for TIMSS 2003 4th grade, TIMSS 2007 8th grade, and PISA 2009. Analysis of data revealed that "the causal factor(s) behind these [East Asian] countries' strong performance seemingly occurs much earlier in life (i.e., before the age of 9/10) and this relative advantage is then maintained" (Jerrim & Choi, 2014, p. 14). In their opinion, this causal factor was the "quality and status of teachers" (p. 18) in East Asia. Several practices reflect this valuing. In terms of teacher recruitment, there is a common policy expectations that prospective teachers are among the top academic performers at school (Jerrim & Choi, 2014).

Teachers in societies which value the profession are also expected to be interacting regularly with education research (Jerrim & Choi, 2014). For example, 100 hours of professional development annually is required of teachers in Singapore. In fact, findings of the Teacher Education and Development Study in Mathematics [TEDS-M] (Hsieh et al., 2010) indicated that preservice elementary school teachers in the East Asian jurisdictions of Singapore and Taiwan possessed better mathematics and mathematics teaching competences than their peers in Western nations (e.g., in Germany and the USA). As a result of the societal valuing of the *teaching profession*, teachers enjoy societal respect (Jerrim & Choi, 2014), good pay, and good working conditions (Boylan, 2019).

Not Valuing *Self-Concept*. So far, we have reported on prior research conducted at the macroeducation level which revealed the values underlying East Asian students' achievement in mathematics. Our review of this body of literature also picked up one value which has been identified in several research studies to be one that was not underlying these students' achievement in mathematics, namely, students' *self-concept*.

A student's mathematics self-concept reflects that "student's beliefs in his or her own mathematics abilities" (OECD, 2013, p. 88). Several studies (e.g., OECD, 2013) have noted the positive correlation between students' self-concepts and their mathematics achievement. However, does this positive correlation apply across all jurisdictions or cultures? Marsh and Hau's (2004) analysis of PISA 2000 scores of 26 jurisdictions led them to conclude that this relationship seemed to apply to Western countries only. In fact, Wilkins' (2004) analysis of the results of 41 jurisdictions in TIMSS 1995 revealed that the better-performing Asian and Eastern European students had lower mathematical self-concepts compared to their peers in Middle Eastern, Western European, American, and Australasian mathematics education systems. Similarly, Lee's (2009) analysis of the results of 41 jurisdictions taking part in the PISA 2003 cycle found that students from the top 10 performing jurisdictions, including in particular Hong Kong, Japan, and Korea, had lower mathematics self-concepts than other students. The same set of PISA 2003 data were also analyzed by Stankov (2010), who focused on a subset of nine jurisdictions which performed well, four of which being East Asian. The findings were similar: students from the East Asian jurisdictions reported lower mathematics self-concepts compared to their peers from Western European countries.

This phenomenon in which East Asian students reported low mathematics self-concepts and low expectancies despite being the best performers in the world could have come about as a result of the Confucian heritage culture in which these students lived and studied. Specifically, Leung (2014) attributed the students' low self-concepts to a cultural valuing of the examinations, modesty, and academic achievement. Similarly, Tao and Hong (2014) identified two related Confucian values, academic *achievement*, and *obligation* to family. It is thus reasonable to see how students' mathematics self-concepts are negatively affected as they function in such an environment.

However, despite the low self-concepts possessed by many students in East Asian jurisdictions, self-concept still positively predicts mathematics achievement for students in Hong Kong, Singapore, and Taiwan (e.g., Chen, 2014; Ker, 2017; Wang et al., 2012). In fact, Liou's (2014) analysis of Taiwanese students' data found that the increments in student mathematics achievements have a stronger relationship with their self-concepts for 8th graders than for 4th graders, and for the students near the top end than those near the lower end. Her explanation has been that 8th graders have to face high-stakes examinations and high pressure arising from peer competition in a culture which values academic *achievement*. *Self-concept* might also perhaps be more valued among adolescents as well, a phase in life for the 8th graders.

Recommendations for Future Research

During the process of researching for writing this *Handbook* chapter, it became evident from assessing smaller-scale studies that there might exist some values which could be potential factors for East Asian students' mathematics achievement but which were not included in the discussion in the recent literature due to a variety of theoretical and practical reasons. An important practical reason is that the values concerned might not have been discerned from the survey designs of PISA or TIMSS.

One such potential factor relates to the religious values embraced by students, teachers, and the learning/school communities. The distribution of religious affiliations within each culture is understandably different, though the impact of students', teachers', and communities' religious values on the effectiveness of mathematics education has seldom been studied. Leu's (2005) qualitative research with a Taiwanese elementary mathematics teacher demonstrated how a teacher's religious values can not only shape their own outlook on life but this outlook is also expressed through the teacher's teaching practices and expectations of her or his students' learning. Even though policies and institutional practices might strive to be secular, given the authority of the teacher in East Asian cultures and the time spent on interactions between teachers and students, individual lessons can still be infused with the respective teacher's signature values and other internalized attributes. Although studies involving larger sample sizes investigating religious values and mathematics performance might have been conducted as recently as 2020, there has yet to be any which utilized population-level data, to our knowledge. As such, effects of religious values have been little discussed in this review chapter.

Methodologically, researching effects of religious values can present its own unique challenges. This is particularly the case with interpreting effects on mathematical behavior of religions, signaling the need for collaborative work between relevant religious scholars. For example, there are yet-to-be-published data from research into how the mathematics achievements, expectations, and values of 797 secondary school students in China's Xishuangbanna Dai Autonomous Prefecture might be explained in terms of the dominant Theravada Buddhist culture. It is understood that the data analysis process benefited from the insights of a Buddhist practitioner.

The impact arising from the increasing numbers of migrant students attending school within the various mathematics education systems, given the boom in cross-national movements of humans around the world before 2020 (Pasquetti, 2006), is an area that deserves greater research attention at the macroeducation level. Such research promises to deepen our understanding of how and why students in East Asian jurisdictions attain such high scores in mathematics learning. In Singapore, for example, permanent residents and nonresidents made up 38.3% of the population in 2018 (Zhu & Kaiser, 2020). In Hong Kong, China mainland-born migrants alone accounted for some 31% of the population in 2016 (Zhu & Kaiser, 2020). Shanghai, one of the cities whose students represented China in the PISA cycles, has been the most popular destination city for rural migrants in this most populous country in the world (Lu & Xia, 2016). Students in Singapore, Hong Kong, and Shanghai—and, indeed, anywhere else—may or may not have been born in the respective jurisdictions. The type of migration (e.g., international and selective for Singapore, international but not so selective in Hong Kong, and internal for Shanghai; see Zhu & Kaiser, 2020) also could have implications on the extent of values alignment experienced by the migrant students. These certainly add an important dimension to the heterogeneity of the students in each jurisdiction, creating a situation that is increasingly complex when we try to identify major reasons for East Asian jurisdictions' success in mathematics achievements at both PISA and TIMSS exercises. To what extent, for example, can we attribute a jurisdiction's success to local pedagogical norms and cultures, if the increasingly sizeable numbers of migrant students might have been schooled under different cultural traditions in their home countries before arriving? Indeed, should national-level data be analyzed according to student subgroups which consider migration status, among other criteria? What new value (categories) might be in play?

Concluding Thoughts

This chapter has focused on mathematics education in seven East Asian jurisdictions, namely, Hong Kong, Japan, Korea, Macau, Shanghai, Singapore, and Taiwan, which have consistently led other countries in students' mathematics and numeracy performance scores in both TIMSS and PISA during the last few decades. The macroeducation approach adopted has meant that there can be greater confidence that values identified in this chapter broadly apply across the respective jurisdictions, notwithstanding finer differences that can exist between urban/rural, government/independent, coeducational/single-sex (mathematics) education systems. Nevertheless, it is worth reminding ourselves that despite its megacity status, Shanghai is a city in a much more diverse country, China. Values which characterize mathematics teaching and learning in Shanghai might not apply elsewhere in China.

It is perhaps not in every jurisdiction's interest to produce cohorts of students whose mathematics performance in PISA and/or TIMSS are similar to the East Asian ones, and the emphasis on doing well at school may not be something shared by all countries (Condron, 2011). However, it is fair to say that it is everyone's duty to develop each child to their fullest potential.

There is no silver bullet, no one-size-fits-all factor at either the individual, institutional, or societal level which produces outcomes associated with high achievement (Lee & Lee, 2021). As Jerrim has stated (2015),

> No single factor has stood out as the cause of the difference in achievement between these groups. Rather a combination of socio-economic characteristics, school selection, values placed upon education, out-of-school tuition, work ethic, attitudes towards what drives success and high aspirations for the future, seem to be at play. (p. 328)

Our review of related macroeducation-level research publications has identified the following values to be underlying enabling pedagogical practices accounting for East Asian students' achievement in mathematics assessment exercises, categorized according to the cultural levels at which they operate:

Student	Achievement
	Effort/perseverance
	Long-term orientation
	Product
	Mastery
	Not self-concept
Institutional	Class size
	Student behavior
	School climate
	School size
	Grade repetition
Societal	Teaching profession

These convictions are organized as a complex web of value systems within individuals, institutions, and the wider society. As such, we noted the roles played by intervening values as well, as these had been evident in the research publications reviewed. That this may also mean that a value which is enabling in one culture can turn out to be a risk factor in another, which has been documented in the reviewed literature.

Although mathematics education systems may want to try developing these values in their respective communities as a means of emulating the successes of the East Asian jurisdictions, it is also worthwhile noting that East Asian mathematics education systems have not remained static over the years as they too have responded to evolving needs of living and working in the ever-changing global landscape. Indeed, many of the mathematics curriculum reforms in East Asia have led to practices (e.g., inquiry-based learning) now commonly observed in the West. It would be important to understand the values which sit beneath these pedagogical practices, which get transported across cultures, and how they interact with local values. In this manner, we might become more successful in helping our students acquire deep understanding, flexible skills, and enabling values through their mathematics learning for meaningful living and working in the twenty-first century and beyond.

References

Al-Murani, T., Kilhamn, C., Morgan, D., & Watson, A. (2019). Opportunities for learning: The use of variation to analyse examples of a paradigm shift in teaching primary mathematics in England. *Research in Mathematics Education, 21*(1), 6–24. https://doi.org/10.1080/14794802.2018.1511460

Australian National Assessment Program. (2016). *About*. Retrieved from https://www.nap.edu.au/about

Biggs, J. B. (1996). Western misconceptions of the Confucian-heritage learning culture. In D. A. Watkins & J. B. Biggs (Eds.), *The Chinese learner: Cultural, psychological and contextual influences* (pp. 45–67). CERC and ACER.

Bishop, A. J. (1988). *Mathematical enculturation: A cultural perspective on mathematics education*. Kluwer Academic Publishers.

Bishop, A. J. (1996, June 3–7). *How should mathematics teaching in modern societies relate to cultural values – Some preliminary questions.* Paper presented at the Seventh Southeast Asian Conference on Mathematics Education, Hanoi, Vietnam.

Boylan, M. (2017). Mathematics challenge: England has one of the biggest gaps between high and low performing pupils in the developed world. *The Conversation.* Retrieved from https://www.theconversationmathematicsmaths-challenge-england-has-one-of-the-biggest-gaps-between-high-and-low-performing-pupils-in-the-developed-world-88678

Boylan, M. (2019). Maths: Should English schools look to Switzerland rather than Shanghai for inspiration? *The Conversation.* Retrieved from https://theconversation.com/maths-should-english-schools-look-to-switzerland-rather-than-shanghai-for-inspiration-110107

Brown, G., Micklewright, J., Schnepf, S., & Waldmann, R. (2007). International surveys of educational achievement: How robust are the findings? *Journal of the Royal Statistical Society Series A, 170*(3), 623–646. https://doi.org/10.1111/j.1467-985X.2006.00439.x

Bryan, C. A., Wang, T., Perry, B., Wong, N.-Y., & Cai, J. (2007). Comparison and contrast: Similarities and differences of teachers' views of effective mathematics teaching and learning from four regions. *The International Journal on Mathematics Education, 39*(4), 329–340. https://doi.org/10.1007/s11858-007-0035-2

Chang, F.-C. (2021). 教育年數與數學學習成就關聯之研究：以國民所得與性別平等為中介變項 [The relationship between education years and math learning achievement: Taking per capita income and gender equality as mediators]. *School Administration, 134*, 219–251. https://doi.org/10.6423/hhhc.202107_(134).0011

Chen, Q. (2014). Using TIMSS 2007 data to build mathematics achievement model of fourth graders in Hong Kong and Singapore. *International Journal of Science and Mathematics Education, 12*, 151–1545. https://doi.org/10.1007/s10763-013-9505-x

Condron, D. J. (2011). Egalitarianism and educational excellence: Compatible goals for affluent societies? *Educational Researcher, 40*(2), 47–55. https://doi.org/10.3102/0013189X11401021

DeBellis, V. A., & Goldin, G. A. (2006). Affect and meta-affect in mathematical problem solving: A representational perspective. *Educational Studies in Mathematics, 63*(2), 131–161. https://doi.org/10.1007/s10649-006-9026-4

Elliott, J. G., Stankov, L., Lee, J., & Bechmann, J. F. (2019). What did PISA ever do for us? The potential of large-scale datasets for understanding and improving educational practice. *Comparative Education, 55*(1), 133–155. https://doi.org/10.1080/03050068.2018.1545386

Ernest, P. (1989). The impact of beliefs on the teaching of mathematics. In P. Ernest (Ed.), *Mathematics teaching: The state of the art* (pp. 249–254). Flamer.

Guglielmi, R. S., & Brekke, N. (2018). A latent growth moderated mediation model of math achievement and postsecondary attainment: Focusing on context-invariant predictors. *Journal of Educational Psychology, 110*(5), 683–708. https://doi.org/10.1037/edu0000238

Halstead, J. M., & Taylor, M. J. (2000). Learning and teaching about values: A review of recent research. *Cambridge Journal of Education, 30*(2), 169–202. https://doi.org/10.1080/713657146

Hannula, M. (2012). Exploring new dimensions of mathematics-related affect: Embodied and social theories. *Research in Mathematics Education, 14*(2), 137–161. https://doi.org/10.1177/2096531120928084

Hofstede, G., & Bond, M. H. (1988). The Confucius connection: From cultural roots to economic growth. *Organizational Dynamics, 16*(4), 5–21. https://doi.org/10.1016/0090-2616(88)90009-5

Hsieh, F.-J., Wang, T.-Y., Hsieh, C.-J., Tang, S.-J., Chao, G., Law, C.-K., . . ., Shy, H.-Y. (2010). A milestone of an international study in Taiwan teacher education – An international comparison of Taiwan mathematics teacher preparation (Taiwan TEDS-M 2008). Retrieved from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=fdf2df14161cf525fc56f8e12024ff9d4cb743bf

Hsieh, F.-J., Wang, T.-Y., & Chen, Q. (2017). Exploring profiles of ideal high school mathematical teaching behaviours: Perceptions of in-service and preservice teachers in Taiwan. *Educational Studies, 44*(4), 468–487. https://doi.org/10.1080/03055698.2017.1382325

Hu, X., Leung, F. K. S., & Teng, Y. (2018). The influence of culture on students' mathematics achievement across 51 countries. *International Journal of Science and Mathematics Education, 16*(Suppl 1), S7–S24. https://doi.org/10.1007/s10763-018-9899-6

Huang, H.-P., & Yore, L. D. (2003). A comparative study of Canadian and Taiwanese grade 5 children's environmental behaviors, attitudes, concerns, emotional dispositions, and knowledge. *International Journal of Science and Mathematics Education, 1*, 419–448. https://doi.org/10.1007/s10763-005-1098-6

Ingvarson, L., Schwille, J., Tatto, M. T., Rowley, G., Peck, R., & Senk, S. L. (2013). *An analysis of teacher context, structure, and quality-assurance arrangements in TEDS-M countries*. IEA.

Jerrim, J. (2015). Why do East Asian children perform so well in PISA? An investigation of Western-born children of East Asian descent. *Oxford Review of Education, 41*(3), 310–333. https://doi.org/10.1080/03054985.2015.1028525

Jerrim, J., & Choi, A. (2014). The mathematics skill of school children: How does England compare to the high performing East Asian jurisdictions? *Journal of Education Policy, 29*(3), 349–376. https://doi.org/10.1080/02680939.2013.831950

Ker, H.-W. (2016). The impacts of student-, teacher- and school-level factors on mathematics achievement: An exploratory comparative investigation of Singaporean students and the USA students. *Educational Psychology, 36*(2), 254–276. https://doi.org/10.1080/01443410.2015.1026801

Ker, H.-W. (2017). The effect of motivational constructs and engagements on mathematics achievements: A comparative study using TIMSS 2011 data of Chinese Taipei, Singapore, and the USA. *Asia Pacific Journal of Education, 37*(2), 135–149. https://doi.org/10.1080/02188791.2016.1216826

Kim, S., & Choi, C. J. (2021). A cross-cultural examination of socio-psychological resources in mathematics achievement between Korea and the US. *Social Psychology of Education, 24*, 1043–1064. https://doi.org/10.1007/s11218-021-09644-9

Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and Individual Differences, 19*(3), 355–365. https://doi.org/10.1016/j.lindif.2008.10.009

Lee, H., & Lee, J. W. (2021). *Why East Asian students perform better in mathematics than their peers: An investigation using a machine learning approach*. Australian National University Centre for Applied Macroeconomic Analysis. https://cama.crawford.anu.edu.au/sites/default/files/publication/cama_crawford_anu_edu_au/2021-07/66_2021_leeh_leejw0.pdf

Leu, Y.-C. (2005). The enactment and perception of mathematics pedagogical values in an elementary classroom: Buddhism, Confucianism, and curriculum reform. *International Journal of Science and Mathematics Education, 3*(2), 175–212. https://doi.org/10.1007/s10763-004-3371-5

Leung, F. K. S. (2001). In search of an East Asian identity in mathematics education. *Educational Studies in Mathematics, 47*(1), 35–51. https://doi.org/10.1023/A:1017936429620

Leung, F. K. S. (2005). Some characteristics of East Asian mathematics classrooms based on data from the TIMSS 1999 video study. *Educational Studies in Mathematics, 60*(2), 199–215. https://doi.org/10.1007/s10649-005-3835-8

Leung, F. K. S. (2006). Mathematics education in East Asia and the West: Does culture matter? In F. K. S. Leung, K.-D. Graf, & F. J. Lopez-Real (Eds.), *Mathematics education in different cultural traditions – A comparative study of East Asia and the West* (pp. 1–20). Springer.

Leung, F. K. S. (2014). What can and should we learn from international studies of mathematics achievement? *Mathematics Educational Research Journal, 26*, 579–605. https://doi.org/10.1007/s13394-013-0109-0

Leung, F. K. S. (2017). Making sense of mathematics achievement in East Asia: Does culture really matter? In G. Kaiser (Ed.), *Proceedings of the 13th International Congress on Mathematical Education. ICME-13 Monographs*. Springer. https://doi.org/10.1007/978-3-319-62597-3_13

Leung, F. K. S. (2018). Mathematics education of Chinese communities from the perspective of international studies of Mathematics achievement. In Y. Cao & F. K. S. Leung (Eds.), *The 21st Century mathematics education in China* (pp. 3–26). Springer-Verlag GmbH. https://doi.org/10.1007/978-3-662-55781-5_1

Leung, F. K. S., Graf, K.-D., & Lopez-Real, F. J. (2006). *Mathematics education in different cultural traditions – A comparative study of East Asia and the West*. Springer.

Levi, N. (2013). The impact of Confucianism in South Korea and Japan. *Acta Asiatica, Varsoviensia, 26*, 8–16. Retrieved from http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.desklight-9a3467f0-a586-496e-b516-6db53219a71a/c/12-Levi-ver02-poprawione.pdf

Li, J. (2002). A cultural model of learning: Chinese "heart and mind for wanting to learn". *Journal of Cross-Cultural Psychology, 33*(3), 248–269. https://doi.org/10.1177/0022022102033003003

Li, X., Han, M., Cohen, G. L., & Markus, H. R. (2021). Passion matters but not equally everywhere: Predicting achievement from interest, enjoyment, and efficacy in 59 societies. *PNAS, 118*(11). https://doi.org/10.1073/pnas.2016964118

Liou, P.-Y. (2014). Investigation of the Big-Fish-Little-Pond effect on students' self-concept of learning mathematics and science in Taiwan: Results from TIMSS 2011. *The Asia-Pacific Education Researcher, 23*(3), 769–778. https://doi.org/10.1007/s40299-013-0152-3

Lo, P.-H. (2003). 從 TIMSS 1999 探討國二學生的學習成就與學習時間及國家經濟能力之關係 [The relationship between student achievements, study time and country's economic]. *Science Education Monthly, 256*, 3–11. https://doi.org/10.6216/SEM.200303_(256).0001

Lu, M., & Xia, Y. (2016). *Migration in the People's Republic of China*. Asian Development Bank Institute. Retrieved from https://www.adb.org/sites/default/files/publication/191876/adbi-wp593.pdf

Marginson, S. (2010). Higher education in East Asia and Singapore: Rise of the Confucian model. *Higher Education, 61*, 587–611. https://doi.org/10.1007/s10734-010-9384-9

Marsh, H. W., & Hau, K.-T. (2004). Explaining paradoxical relations between academic self-concepts and achievements: Cross-cultural generalizability of the internal/external frame of reference predictions across 26 countries. *Journal of Educational Psychology, 96*(1), 56–67. https://doi.org/10.1037/0022-0663.96.1.56

National Centre for Excellence in the Teaching of Mathematics (NCETM). (2022). *Mastery explained*. Retrieved from https://www.ncetm.org.uk/teaching-for-mastery/mastery-explained/

National Institute of Education, Singapore (NIE). (2009). *A teacher education model for the 21st century*. National Institute of Education.

Organisation for Economic Co-operation and Development (OECD). (2010). *The high cost of low educational performance*. Retrieved from https://www.oecd.org/pisa/44417824.pdf

Organisation for Economic Co-operation and Development (OECD). (2013). *PISA 2012 results: Ready to learn – Students' engagement, drive and self-beliefs* (Vol. III). OECD Publishing. https://doi.org/10.1787/9789264201170-en

Pan, Y., Zhong, J., Hill, J. L., & Seah, W. T. (2022). *Values which facilitate mathematical wellbeing of Chinese primary school students: A preliminary study*. Refereed paper presented at the 12th Congress of the European Society for Research in Mathematics Education, Bozen-Bolzano, Italy. https://storage.ibrida.io/public/cerme12/TWG08/paper/Pan_TWG08_final.pdf

Pang, J., & Seah, W. T. (2020). Excellent mathematical performance despite "negative" affect of students in Korea: The values perspective. *ECNU Review of Education, 4*(2), 285–306. https://doi.org/10.1177/2096531120930726

Pasquetti, S. (2006). Do we need an international regime for migration? In R. J. Langhammer & F. Foders (Eds.), *Labor mobility and the world economy* (pp. 209–224). Springer.

Pratt, D. D., Kelly, M., & Wong, W. (1999). Chinese conceptions of 'effective teaching' in Hong Kong: Towards culturally sensitive evaluation of teaching. *International Journal of Lifelong Education, 18*(4), 241–258. https://doi.org/10.1080/026013799293739a

Probert, S. (2021). Policy transfer and isomorphism: A case study of the England-China maths teacher exchange. *British Journal of Educational Studies*. https://doi.org/10.1080/00071005.2021.1926915

Rohaeti, E. E. (2016). Integrating Japanese values in teaching mathematics in Indonesia. *Man in India, 96*(4), 1235–1246. https://serialsjournals.com/abstract/64706_32.pdf

Sandoval-Hernández, A., & Białowolski, P. (2016). Factors and conditions promoting academic resilience: A TIMSS-based analysis of five Asian education systems. *Asia Pacific Education Review, 17*, 511–520. https://doi.org/10.1007/s12564-016-9447-4

Scardino, M. (2008, December 11). The Olympics of education: Fresh efforts to boost the UK in maths and science league tables will also help our economic health. *The Guardian.* Retrieved from https://www.theguardian.com/education/2008/dec/11/primary-maths-science-politics

Schmidt, W. H., Houang, R., & Cogan, L. S. (2012). Preparing future math teachers. *Science, 332*, 1266–1267. https://doi.org/10.1126/science.1193855

Seah, W. T. (2019). Values in mathematics education: Its conative nature, and how it can be developed. *Research in Mathematics Education, 22*(2), 99–121. https://doi.org/10.7468/jksmed.2019.22.2.99

Serrat, O. (2017). *Knowledge solutions: Tools, methods, and approaches to drive organizational performance*. Springer.

Stankov, L. (2010). Unforgiving Confucian culture: A breeding ground for high academic achievement, test anxiety and self-doubt? *Learning and Individual Differences, 20*, 555–563. https://doi.org/10.1016/j.lindif.2010.05.003
Stern, P., Dietz, T., Abel, T., Guagnano, G., & Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case of environmentalism. *Human Ecology Review, 6*(2), 81–96. http://www.jstor.org/stable/24707060
Stevenson, H. W., Lee, S.-Y., Chen, C., Stigler, J. W., Hsu, C.-C., Kitamura, S., & Hatano, G. (1990). Context of achievement: A study of American, Chinese, and Japanese children. *Monographs of the Society for Research in Child Development, 55*(1–2), 1–199. https://doi.org/10.2307/1166090
Tao, V., & Hong, Y.-Y. (2014). When academic achievement is an obligation: Perspectives from social-oriented achievement motivation. *Journal of Cross-Cultural Psychology, 45*(1), 110–136. https://doi.org/10.1177/0022022113490072
Thomas, G. P. (2006). An investigation of the metacognitive orientation of Confucian-Heritage Culture and Non-Confucian-Heritage Culture science classroom learning environment in Hong Kong. *Research in Science Education, 36*, 85–109. https://doi.org/10.1007/s11165-005-3915-x
Tiberius, V. (2018). *Well-being as value fulfillment: How we can help each other to live well*. Oxford University Press.
Wang, T.-Y., & Hsieh, F.-J. (2017). Taiwanese high school students' perspectives on effective mathematics teaching behaviors. *Studies in Educational Evaluation, 55*, 35–45. https://doi.org/10.1016/j.stueduc.2017.06.001
Wang, Z., Osterlind, S. J., & Bergin, D. A. (2012). Building mathematics achievement models in four countries using TIMSS 2003. *International Journal of Science and Mathematics Education, 10*, 1215–1242. https://doi.org/10.1007/s10763-011-9328-6
Wilkins, J. L. M. (2004). Mathematics and science self-concept: An international investigation. *The Journal of Experimental Education, 72*(4), 331–346. https://doi.org/10.3200/JEXE.72.4.331-346
Wong, N. Y., Wong, W. Y., & Wong, E. W. Y. (2012). What do Chinese value in (mathematics) education? *ZDM – Mathematics Education, 44*(1), 9–19. https://doi.org/10.1007/s11858-012-0383-4
Wu, M. (2011). Using PISA and TIMSS mathematics assessments to identify the relative strengths of students in Western and Asian Countries. *Journal of Research in Education Sciences, 56*(1), 67–89. https://doi.org/10.3966/2073753X2011035601003
Xu, K. M., Cunha-Harvey, A. R., King, R. B., de Koning, B. B., Paas, F., Baars, M., Zhang, J., & de Groot, R. (2021). A cross-cultural investigation on perseverance, self-regulated learning, motivation, and achievement. *Compare: A Journal of Comparative and International Education, 53*, 361. https://doi.org/10.1080/03057925.2021.1922270
Yang, S.-C., Peng, L.-H., & Hsu, L.-C. (2019). The influence of teacup shape on the cognitive perception of tea, and the sustainability value of the aesthetic and practical design of a teacup. *Sustainability, 11*(24), 6895. https://doi.org/10.3390/su11246895
Zhang, Q., Barkatsas, T., Law, H. Y., Leu, Y.-C., Seah, W. T., & Wong, N.-Y. (2016). What primary students in the Chinese Mainland, Hong Kong and Taiwan value in mathematics learning: A comparative analysis. *International Journal of Science and Mathematics Education, 14*(5), 907–924. https://doi.org/10.1007/s10763-014-9615-0
Zhu, Y., & Kaiser, G. (2020). Do East Asian migrant students perform equally well in mathematics? *International Journal of Science and Mathematics Education, 18*, 1127–1147. https://doi.org/10.1007/s10763-019-10014-3
Zhu, Y., & Leung, F. K. S. (2011). Motivation and achievement: Is there an East Asian model? *International Journal of Science and Mathematics Education, 9*, 1189–1212. https://doi.org/10.1007/s10763-010-9255-y