

# Excellent Mathematical Performance Despite “Negative” Affect of Students in Korea: The Values Perspective

ECNU Review of Education  
2021, Vol. 4(2) 285–306  
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sagepub.com/journals-permissions  
DOI: 10.1177/2096531120930726  
journals.sagepub.com/home/roe



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## Abstract

**Purpose:** Given the unclear relationship between cognition and affect, this article reports on a study exploring how the conative variable of values may provide some explanation for students with excellent performance despite a negative attitude toward mathematics.

**Design/Approach/Methods:** The study reported in this article represents Korea’s participation in the international “What I Find Important (in my mathematics learning)” [WIFI] study, which assesses the attributes of mathematics learning and teaching that are valued by students. The participants of this study were 816 Korean students who responded to the WIFI questionnaire.

**Findings:** The results of principal component analysis indicated that the following five attributes about mathematics and mathematics pedagogy were valued by Korean students: *understanding*, *connections*, *fun*, *accuracy*, and *efficiency*. These attributes were further analyzed with relation to student gender, school system, and student confidence.

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**Originality/Value:** Korean students' valuing of *understanding* and *connections* is noteworthy. It is hoped that the findings of this study might explain Korean students' exceptional performance despite a generally low affective mode, and extending this further, how values in mathematics education might be a useful construct to help us make sense of the observed mismatch globally between high performance and low affect.

### Keywords

Connections, Korean students, student values, understanding, values and valuing

Date received: 17 December 2019; accepted: 9 May 2020

## Introduction

Korean students have been among the top performers in international mathematics assessment. Fourth graders came in third and eighth graders came in second in the latest Trends in International Mathematics and Science Study (TIMSS) 2015 (Mullis et al., 2016). The 15-year-old students continued their high performance in the Programme for International Student Assessment (PISA) 2018 (OECD, 2019a). Together, these mean that not only do Korean students excel in understanding mathematical knowledge and applying related skills—which are assessed by TIMSS—they are also among the best in the world when it comes to students' ability to apply relevant knowledge and skills in novel mathematical problem situations, which is typically the kind of questions that are featured in the PISA studies.

Yet, at the same time, like most if not all their peers elsewhere, Korean students do not generally display positive affect toward mathematics. They reported almost the lowest confidence and interest in mathematics in comparison with their counterparts participating in TIMSS 2015 (Mullis et al., 2016). More recently, according to the results from PISA 2018 (OECD, 2019b), only 57% of Korean students reported that they are satisfied with their lives (OECD average being 67%), while 75% of students strongly agreed or agreed that they worry about what others think of them when they fail (OECD average being 56%).

The apparent contradiction of Korean students' outstanding performance in mathematics along with their negative attitude toward the subject may be related to the *East Asian Learner Paradox* (Biggs, 1996), referring to the mismatch between superior outcomes and an apparently unfavorable learning environment. Numerous explanations have been offered in response to the paradox, relating to teaching methods (e.g., teachers' skillful coordination between the procedural and conceptual aspects of mathematics), sociocultural factors (e.g., examination-driven culture or Confucian heritage culture), or psychological factors (e.g., students' belief that mathematics is important to enter a good university or to get a job in future) (King & Bernardo, 2016; Leung, 2001; Mok, 2007).

Against the unfavorable attitude toward mathematics, Korea's Ministry of Education (MOE, 2015) has been trying to encourage students to perceive the enjoyment of learning mathematics as well as the usefulness of mathematics and to foster desirable attitude and ability to practice as mathematics learners through the change of the national mathematics curriculum and its concomitant instructional environment. Despite these educational policy efforts, significant changes have yet to take place apparently, as evidenced by recent TIMSS or PISA results.

This situation is not desirable from various aspects. For instance, no (mathematics) education system would want to have cultivated generations of young citizens who fear mathematics or who are stressed by doing mathematics. Also enhancing the positive well-being of individuals is fundamental to shaping and maintaining healthy and thriving communities.

However, what is of interest here is that Korean students performed excellently in mathematics despite most of them having negative affect about mathematics and/or mathematics learning. The common belief has been that positive affect promotes learning (e.g., Shang et al., 2013) and performance (e.g., Ma & Kishor, 1997). Negative emotional traits such as attitudes, self-esteem, beliefs, and efficacy are known to inhibit successful (mathematics) learning. If this is the case, how might we explain Korean students' performance?

Given this unclear relationship between cognition (student performance in mathematics) and affect (students' interest, confidence, engagement, etc.), this article draws on the conative construct of (student) valuing to attempt to understand this relationship more. In the study reported here, what Korean students valued in school mathematics education were mapped. The intention is that an understanding of the attributes of mathematics learning and teaching that are valued by Korean students could provide clues to their exceptional performance despite a generally low/negative affective mode.

In addition, we intend to explore students' values of mathematics learning in conjunction with student gender, school system, and confidence. Gender difference in mathematics achievement has been a controversial issue in Korea. Park (2008) reported that boys were better than girls in mathematics achievement in the Korean context. More recently, fourth-grade boys in Korea gained statistically significant scores higher than their female peers in TIMSS 2015 (Mullis et al., 2016). However, in the same TIMSS 2015, there was no significant difference between eighth-grade boys and girls, even though boys scored slightly higher than girls. The gaps of mathematics performance between Korean boys and girls through the series of PISA since 2000 have tended to notably decrease (only exception happened in PISA 2012). Korean girls attained even higher scores in mathematics than boys in PISA 2015 (OECD, 2016), and girls scored similar to boys in PISA 2018 (OECD, 2019b). These led us to explore how students' valuing in mathematics education would be affected by student gender.

Korean students' negative attitudes toward mathematics have a tendency to be worse in a secondary school. For instance, in TIMSS 2015 (Mullis et al., 2016), only 13% of the Korean fourth graders were *very confident* in mathematics and 51% of them were confident (OECD averages are 32% and 45%, respectively). However, only 8% of the Korean eighth graders were *very confident* in mathematics and 38% of them were confident (OECD averages are 14% and 43%, respectively). In a similar vein, the percentage of eighth graders who reported they *very much liked* or liked learning mathematics was remarkably decreased in comparison to that of fourth graders. These also led us to explore how students' valuing in mathematics education would be affected by student grade levels in school and their confidence in mathematics learning.

It will be necessary to first introduce the values framework, reviewing relevant research that might be useful for the current study. The methodology of the study will be introduced next, with reference to the international "What I Find Important (in my mathematics learning)" [WIFI] study. Data analysis will seek to contribute toward addressing the following research questions:

1. What do primary and secondary school students in Korea value in their school mathematics learning experience?
2. How might the students' valuing be affected by student gender, student grade levels in school, and student confidence in mathematics learning?

### **The "valuing in mathematics education" framework**

A detailed theoretical overview of values-related constructs (e.g., values, emotions, affect, confidence, motivation, beliefs, and attitudes) is not the intention of this section and in fact such an overview will be beyond the scope of this article. Various aspects of values have been addressed by different researchers depending on their theoretical orientations and educational purposes (Clarkson et al., 2019).

Values in mathematics education research have generally been mentioned with relation to attitudes, beliefs, and affect. According to Philipp (2007), beliefs together with emotions and attitudes are one of the three subcomponents of affect. Here, emotions as feelings of consciousness change more rapidly than attitudes and beliefs, while beliefs are more cognitive than attitudes and emotions. Value is described as a "belief one holds deeply, even to the point of cherishing, and acts upon" (Philipp, 2007, p. 259) or regarded as beliefs in action (Clarkson et al., 2000). In this sense, Philipp's (2007) conception echoes the seven criteria of what becomes a value that was proposed earlier by Raths et al. (1987), namely, choosing freely, choosing from alternatives, choosing after thoughtful consideration of the consequences of each alternative, prizing and cherishing, affirming, acting upon choices, and repeating.

Here, we differentiate values from beliefs even more. We argue that they are basically different in nature. A look at any list of corporate/institutional/school values would reveal the difference. While values reflect what are regarded as important and worthwhile, beliefs are expressions of what are right or wrong. The emphasis on “choosing” and “choice” by Raths et al. is regarded as significant in differentiating values from beliefs (Bishop, 2014). The researchers claim that either belief or attitude may miss some of the criteria mentioned above, even though they did not specify what criteria that belief or attitude is missing. A student may have several beliefs about learning mathematics, but values are bound to manifest in making specific choices from different alternatives. Values and related beliefs need not correlate. Thus, a student may value *practice*, but this does not necessarily mean that she/he believes that mathematics homework should be a daily feature of schooling.

While some researchers identify values within the affect domain (e.g., Hannula, 2012; Philipp, 2007), Seah and some others differentiate values from affect. For instance, Seah and Andersson (2015) regard values as a volitional variable which regulates both cognitive skills and emotional dispositions. More recently, Seah (2019) proposes values as a conative variable separating from both cognition and affect, and explains conation as a bridge between cognition and affect, and behavior. In this perspective,

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. In the process, the conative variable also regulates the individual’s activation of cognitive skills and affective dispositions in complementary ways. (Seah, 2019, p. 107)

This study’s investigation of what students value is guided by the above theoretical framework which we refer to as “valuing in mathematics education.” Two interrelated sociocultural components are operationalized, namely, values in the mathematics classroom (Bishop, 1996) and value continua (Hofstede et al., 2010). The former provides a framework with which we consider attributes of mathematics, of its pedagogy, and of school education in general that are considered important by Korean students in their mathematics learning. The latter emphasizes the relative strengths to which these attributes are valued along value continua, instead of opposing values existing in a valued/not valued dichotomous relationship.

### *Values in the mathematics classroom*

Different kinds of values are expressed by teachers and their students in the classroom as they interact with one another. For the mathematics classroom, Bishop (1996) conceptualized these as general educational values, mathematical values, and mathematics educational values.

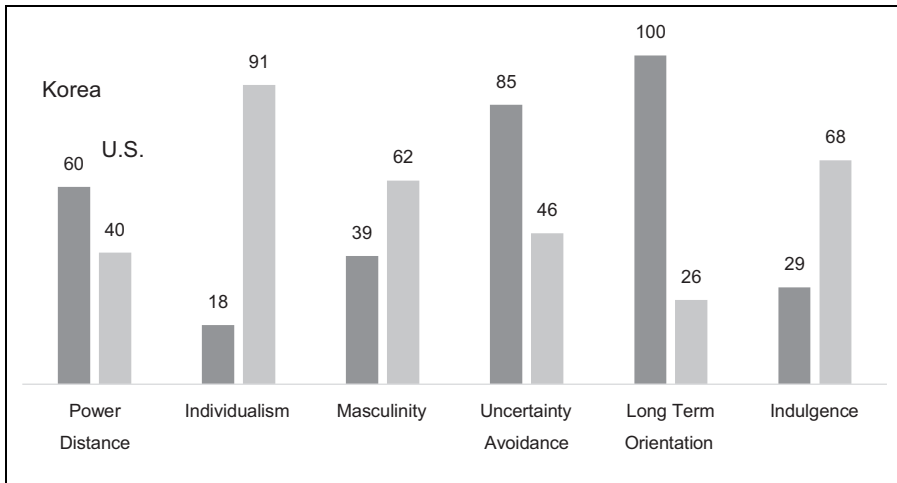
Mathematics lessons do not take place in a vacuum that is void of context. Teachers often find themselves inculcating in their students' values that are generally educational in nature. Examples of these general educational values include *perseverance* and *respect*. Mathematical values refer to attributes of the mathematics discipline that are considered important, and Bishop (1988) had earlier proposed that three pairs of complementary values can be associated with "Western" mathematics, namely, *rationalism* and *objectism*, *control* and *progress*, and *mystery* and *openness*.

On the other hand, mathematics educational values relate to aspects of mathematics pedagogy that are considered important. The competencies that are promoted in many current mathematics curricula may be considered to be mathematics educational values, for they represent attributes of mathematics learning that students are encouraged to embrace. For example, the Victorian mathematics curriculum clarifies that "the proficiencies of Understanding, Fluency, Problem-Solving and Reasoning are fundamental to learning mathematics and working mathematically" (VCAA, 2017, n.p.). In a similar vein, the most recent Korean mathematics curriculum emphasizes six competencies: Problem-Solving, Reasoning, Communication, Creativity or Convergence, Data Processing, and Attitude or Practice (MOE, 2015).

Recent empirical studies on values in mathematics learning, notably from the WIFI study, demonstrate diverse mathematics educational values across different regions. For instance, students in Hong Kong SAR valued *explorations*, *alternative approaches*, *effort*, (*mathematics*) *identity*, *recall*, *Information and Communications Technology (ICT)*, *feedback*, *applications*, and *exposition*, whereas their peers in Japan valued *wonder*, *creativity*, *results*, *others' involvement*, *know-how*, *ICT*, *discussion*, *reality*, and *mystery* (Seah et al., 2017). Furthermore, Zhang et al. (2016) investigated students' values in mathematics learning across East Asia. The researchers identified six common components in the students' values (i.e., *achievement*, *relevance*, *practice*, *communication*, *ICT*, and *feedback*) although, understandably, there were statistically significant differences among the different regions in each of the six value components. Yet, for a country which consistently performs excellently in international mathematics assessments and which has been leading the world in the Gross Domestic Product ranking, what Korean students value in their mathematics learning has hitherto not been researched. As such, the conduct of this study in Korea is expected to offer valuable information with regard to the conative aspects of Korean students' mathematics learning. This can lead to our developing an overall picture of how Korean students learn (best), taking in the cognitive, affective, and conative aspects.

### **Cultural dimensions**

From a sociocultural perspective, the (mathematics) classroom is also a space where values embraced at the wider, societal level are being played out. In this context, empirically derived cultural dimensions by Hofstede et al. (2010) have been one of the most influential constructs.



**Figure 1.** Comparing the cultural dimensions of Korea and the U.S.

Geert Hofstede's initial questionnaire data from 40 countries had led to the formulation of four dimensions of cultural values, with an assertion that no two culture shares the same four ordinate positions. These four dimensions relate to variable valuing of power distance (the extent to which power is distributed evenly, and hierarchy is nonexistent), collectivism (the extent to which members of a culture function as a group), uncertainty avoidance (the extent to which change is resisted), and femininity (the extent to which a culture exercises care and concern, over competition, and assertiveness). Ongoing work over the years had led to the identification of two additional dimensions, namely, short-term orientation (the extent to which a culture holds on to its past and is cautious about the present and future) and restraint (the extent to which a culture allows relatively free gratification of desires).

An important feature of values is that they are located along continua (see, e.g., Hofstede et al., 2010). In other words, instead of considering if an attribute is valued or not, we believe that it is more meaningful to consider the extent to which the attribute is valued. That is, if a student finds *mental computation* important, say, it does not mean that she/he does not find it important for calculators to be used in mathematics learning. This student may still find it important and efficient for the calculator to be used in executing some mathematical procedures.

Korea's cultural dimension profile is shown in Figure 1, in comparison with the U.S. profile (Hofstede et al., 2010) as an example to represent visually the uniqueness of the Korean cultural dimensions. Figure 1 indicates that Korea values power distance, such that students are brought up to accept the authority of teachers and schools without question. It is also very collectivistic. Korea is also feminine, meaning that students and teachers value quality time with each other at school,

and that conflicts are preferably resolved through compromise and negotiation, with a focus on well-being. In the fourth dimension of “uncertainty avoidance,” Korea’s high score means that students and teachers expect and require rules in school and find it important to be busy at work. The Korean society is also extremely long-term oriented, and when applied to students and their teachers, this can mean that their commitment to studies reflects a valuing of an investment in a secured future. These are all accompanied by the country’s low score on the “indulgence” dimension, which indicates that students and teachers in Korea probably do not place much emphasis on leisure time nor on satisfying what’s desired emotionally. We can see how Korea and the U.S. value the six cultural dimensions differently, with the differences being especially pronounced for the collectivism and long-term orientation dimensions.

It is our belief that the attributes that have been inculcated in—and subsequently valued by—students and their teachers reflect not just Bishop’s (1996) values in the mathematics classroom, but also the non-pedagogical, societal values that are encapsulated in Hofstede’s cultural dimensions. The societal values embraced by individuals reflect what are deemed to be important in their own respective cultures, which as Hofstede et al. (2010) pointed out form a profile that is unique to the particular cultures. A teacher or student’s valuing of, say, high (or low) *power distance*, for example, would impact on the quality of teacher–student and peer interactions in the mathematics classroom. As such, we believe that any attempt at unpacking and understanding what and how school mathematics learning takes place should also be referenced against all these categories of values and valuing.

## Methodology

The research study being reported here is the Korean component of the 18-nation “What I Find Important (in my mathematics learning)” [WIFI] study (Seah et al., 2017). Accordingly, the research methodology that was adopted is the same as that of the WIFI study, which will be outlined below.

### *The WIFI questionnaire*

The WIFI study was designed to identify what individual students value in their personal mathematics learning experiences. Contemporary approaches to measuring values and valuing tended to employ the methods of lesson observations and/or interviews (see, e.g., Keitel, 2003; Tan & Lim, 2013), which has also meant small sample sizes. However, anecdotal evidence suggested that not only do small sampling sizes affect generalizability, the length of time required to assess student values has also been a disincentive for classroom teachers.



Section A					
For each of the items below, tick a box to tell us how <b>important</b> it is to you when you learn mathematics.					
	Absolutely important	Important	Neither important nor unimportant	Unimportant	Absolutely unimportant
1. Investigations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Problem-solving	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Small-group discussions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Figure 2.** Some of the Likert-type scale items from Section A of the WIFI questionnaire.

Thus, the questionnaire method should allow for quick and efficient collection of data from a large participant pool. This, and the generalizability which it affords, can stimulate more teachers or their schools to use their knowledge of what their students value to inform pedagogical decisions.

After all, the questionnaire had been used in prior research to accurately assess values (see, e.g., Johnson & Christensen, 2010; Reichers & Schneider, 1990). Even though values questionnaires also exist in other research areas (e.g., Rokeach, 1973; Senge et al., 1994), the WIFI questionnaire had been designed specially to survey broadly what students find important (i.e., value) corresponding to Bishop's (1996) categories of mathematical, mathematics educational, and general educational values respectively. The WIFI questionnaire items were drawn from relevant sources and were validated (see Seah et al., 2017 for the development of the items).

In particular, the WIFI questionnaire items were developed to identify respondents' valuing of the 6 mathematical values in Bishop (1988), the 10 mathematics educational values identified through Seah's (1999) study, and the 6 general educational values which are expressed by Hofstede et al. (2010) in the form of value continua. These were elicited through respondents indicating the extent to which they find particular learning activities (e.g. small-group discussions) important from the 64 Likert-type scale items with five choices each (see Figure 2), as well as the extent to which they valued an attribute of mathematics learning more than an opposing attribute (e.g. *process* and *product*) from the 10 slider scale items (see Figure 3). In particular, the slider

**Section B**

For each pair of phrases below, mark on the line segment to indicate how more important one phrase is to you in your maths learning than the other phrase.

If you mark in the middle, it would mean that both phrases are equally important to you.

**Example (non-maths):**

Watching a movie        ✓        Shopping

66.      *How the answer to a problem is obtained*    \_\_\_\_\_    *What the answer to a problem is*

67.      *Feeling relaxed or having fun when doing maths*    \_\_\_\_\_    *Hardwork is needed when doing maths*

**Figure 3.** Some of the slider scale items from Section B of the WIFI questionnaire.

scale items reflect Bishop's (1988) idea of complementary value pairs, and Hofstede et al.'s (2010) notion of value continua.

During the design phase for the questionnaire, it was also considered that there might be attributes valued by particular students but which are not "captured" by the Likert-type scale and slider scale items. Even though these items were drawn from previous studies and established models, there may well be certain attributes of mathematics education which are unique to Korea and which Korean students valued. For this reason, the questionnaire also included one contextualized open-ended question, so that respondents are able to list freely what is important to their mathematics learning. Only the findings from the 64 Likert-type scale items as well as the demographic and personal information (e.g., grade level, gender, and confidence in school mathematics) are reported in this article.

### *Procedures and participants*

Given that the WIFI questionnaire is written in the English language, it needed to be translated into Korean before it was administered to the students. The questionnaire translated into Korean by the research team was translated back into English by a group of five teachers who earned a doctoral degree in mathematics education. Whenever there were differences, discussions among the whole group were continued until full agreement was reached. A pilot test with the translated questionnaire was administered to 30 sixth graders and 30 ninth graders. Several vocabularies such as "proofs" or "theorems" were problematic because they were unfamiliar or vague to students. Some

**Table 1.** Distribution of Korean student participants.

Location	Primary school students (Grade 6)		Secondary school students (Grade 9)	
	Number of schools	Number of students	Number of schools	Number of students
Seoul	3	59	2	61
Metropolitan city	4	112	3	116
Small city	8	152	7	166
Rural area	4	86	3	62
Total	19	409	15	407

English expression was also difficult for the sixth graders. Against these difficulties, the meaning was clarified or an example needed to be added under such vocabularies.

To collect the questionnaire data, a total of 34 schools (19 primary and 15 secondary schools) were purposefully selected across the country by stratified cluster sampling of school locations and the number of students. Among the 34 schools, 5 schools were located in Seoul, 7 schools were in metropolitan cities, 15 schools were in small cities, and 7 schools were in rural areas.

The questionnaire was administered online using the SurveyMonkey platform. One teacher in each selected school was informed of the overall purpose of this study as well as the website address. Along with the teacher's guidance, his or her students completed the questionnaire mostly using a computer lab or otherwise their smart phones. In cases of any difficulties to access the website, students responded to hard copies of the questionnaire in class. 925 students were eligible to take part, although a total of 816 students completed the questionnaire (i.e., response rate of 88%). The distribution of the student participants is presented in Table 1. Among these 816 students, all but 5 of them declared their sex. There were 348 boys and 463 girls among these 811 students.

### *Value coding exercise*

The Likert-type scale items represent learning activities such as “knowing which formula to use” (item 58), each of which had been chosen to reflect particular valuing. However, during the data analysis phase, we are mindful that what students valued cannot be deduced from single learning activities alone. A student who values *fluency* would rate “knowing which formula to use” as being (very) important, but another student who values *efficiency* or *product* (vs. *process*), say, would also rate this item similarly.

Thus, prior to any work with the collected questionnaire data, the value(s) corresponding to each of the Likert-type scale items of classroom activities—as understood from the Korean perspective—was identified. Some items were identified as corresponding to one value, while

others were corresponded to multiple values. For instance, item 54 (i.e., understanding concepts or processes) was agreed by members of the Korean team as corresponding to the valuing of *understanding*. However, item 36 (i.e., practicing with lots of questions) was regarded by the same members as corresponding to the values of *effort*, *fluency*, *perseverance*, and *practice*. In this way, the value(s) was identified by the team of three Korean researchers considering the 64 items one at a time, proposing and comparing their personal judgments of what the associated underlying value(s) might be, and working together to arrive at mutually agreed value(s). This value coding exercise served as a basis when the Korean researchers as “cultural insiders” had to assign a value name to each component resulting from subsequent factor analysis process. As Seah et al. (2017) propose, the culturally situated labeling of values and valuing is appropriate, mainly because even the same learning activities can be differently valued by students in different cultures or educational systems.

### *Data analysis*

A quantitative approach was adopted to analyze the questionnaire data. The collected data were first entered into a common data entry spreadsheet used by all the WIFI research teams. Following data screening and testing for univariate normality, an exploratory factor analysis was conducted to investigate how the questionnaire items might relate to one another. Details are presented below alongside the reporting of analysis results.

## **Results**

### *Principal component analysis*

The questionnaire items were initially subjected to an exploratory factor analysis using SPSSwin (Version 25). The extraction method used was principal component analysis (PCA) and the rotation method was a Varimax with Kaiser Normalization to examine the items. The significance level was set at .05, while a cutoff criterion for component loadings of at least .45 was used in interpreting the solution. Given that the minimum component loading in PCA is often .4, the cutoff at .45 was chosen for this study to align with the same value being used in the other research teams in the project group, to facilitate cross-cultural analyses in future. The rotation converged in 22 iterations. Further, the Kaiser–Meyer–Olkin measure of sampling adequacy was .97 (far greater than the threshold value of .6) and Bartlett’s test of sphericity was significant at the .001 level. Thus, factorability of the correlation matrix was assumed, which confirmed the usefulness of the PCA.

According to the cutoff criterion, 56 from the original 64 items were retained. The resulting rotated matrix consisted of nine components, each with eigenvalue greater than 1, but four of them (i.e., C4, C6, C8, and C9) were eliminated based on the common practice of excluding components

with just 1 or 2 items which were treated as weak factors. The remaining five components with a total of 49 items explained 48.49% of the total variance. The five components were labeled by the full agreement among the Korean researchers as an attempt to identify the culturally situated meanings for the learning activities that were valued by Korean students. The resulting names of the five components are *understanding* (C1), *connections* (C2), *fun* (C3), *accuracy* (C5), and *efficiency* (C7). The Cronbach's  $\alpha$  for the overall scale is .969, and those for the components indicate high or acceptable levels of item reliability for all five components.

*Understanding (C1).* The first component consists of 26 items which explains 21.513% of the total variance. The valuing of *understanding* is associated with the students placing importance on understanding concepts and processes (item 54), which might involve the use of concrete materials (item 48), of diagrams (item 47), of examples (item 49), of hands-on activities (item 52), and teacher use of related keywords (item 53). Understanding is not achieved through teacher pedagogical approaches alone, but it can also be facilitated through the students' own learning habits, such as practicing with lots of mathematics questions (item 36), working out the mathematics themselves individually (item 42), looking out for different ways to find the answer (item 15), looking out for shortcuts (item 55), knowing the steps of the solution (item 56), knowing when to use particular, given formula (items 38 and 58), working step-by-step (item 6), writing out the solutions in the process (item 33), using mathematical words (item 32), getting the right answer (item 50), completing mathematics work (item 62), and remembering the work that has been done (item 64). Learning through mistakes (item 51) is also a way of enhancing understanding, including understanding why the solution presented is right or incorrect (item 63). To the students in Korea, understanding is also fostered through having knowledge of the theoretical aspects of mathematics (item 59), engaging in problem-solving (item 2), and appreciating the relationship between mathematics concepts (item 26). Lastly, the students also emphasize the interactional aspects involved in attaining understanding, with teachers and students asking one another questions (items 35 and 46).

*Connections (C2).* The second component consists of 13 items which explains 14.942% of the total variance. The valuing of *connections* is associated with the students relating mathematics to other subjects in school (item 10), connecting mathematics to real life (item 12), looking out for mathematics in real life (item 39), and posing mathematics problems (item 21). Not only such external connections of mathematics to various contexts outside of mathematics, the students in this study did place the importance of internal connections within mathematics by appreciating the beauty of mathematics (item 11), recognizing the stories about mathematics and recent developments in mathematics (items 17 and 18). Investigations and mathematics puzzles (items 1 and 20) can also be a way of using mathematical ideas in an interconnected

manner. Lastly, connections among mathematical ideas are also fostered for Korean students by explaining their solutions to the class (item 19), making up their own questions (item 29), participating in mathematics debates (item 9), or looking for different possible answers (item 16).

*Fun (C3)*. The third component consists of 4 items which explains 5.141% of the total variance. The valuing of *fun* is related to the students placing importance on mathematics games and outdoor mathematics activities (items 25 and 34) as well as learning mathematics with the computer or the Internet (items 23 and 24).

*Accuracy (C5)*. The fourth component consists of 3 items which explains 3.618% of the total variance. The valuing of *accuracy* is related to the students placing importance on getting the correct answer (item 27) and using the calculator either to check the answer or to calculate (items 4 and 22).

*Efficiency (C7)*. The fifth component consists of 3 items which explains 3.274% of the total variance. The valuing of *efficiency* is related to students' preference of explanation by the teacher (item 5), rather than to their own struggle to solve a given problem. Memorizing facts (item 14) or knowing the times tables (item 28) can also be an efficient way to solve problems quickly.

### *Multivariate analysis of variance*

To investigate student gender, school system, and student confidence statistically significant differences for each of the five components, multivariate analyses of variance (MANOVA) were conducted. The dependent variables were the five components derived from the PCA, and the independent variables were *student gender*, *school system*, and *student confidence* respectively. The MANOVA findings are discussed next.

An initial data screening was carried out to test for univariate normality, multivariate outliers (Mahalanobis' distance criterion), homogeneity of variance-covariance matrices (using Box's M tests), and multicollinearity and singularity (tested in the MANOVA analysis). Descriptive statistics normality tests (normal probability plot, detrended normal plot, Kolmogorov-Smirnov statistic with a Lilliefors significance level, Shapiro-Wilk statistic, skewness, and kurtosis) showed that assumptions of univariate normality were not violated. Thus, the five components are ready for multivariate analysis.

Mahalanobis' distance was calculated, and a new variable was added to the data file. The critical value of  $\chi^2$ , for five dependent variables, at the  $\alpha$  level of .001 is 20.5. Accordingly, there were 12 outlying cases which are not unexpected in a sample size of 816 students. These outliers were therefore retained in the data set.

Box's M Test of equality of covariance matrices (which tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups) was significant at the .001  $\alpha$  level for student gender, school system, and student confidence. Thus, we do not have homogeneity of variance for the three independent variables. This suggests that the Pillai's Trace criterion might be a more robust multivariate test of significance to use in this current study, rather than, say, Wilks' Lambda.

Levene's test of equality of error variances has been used to test for homogeneity of variance for each of the dependent variables. The tests indicate that homogeneity has not been violated for two of the five components, with an  $\alpha$  level of 0.05. However, for *understanding* (C1), *connections* (C2), and *fun* (C3), the Levene's test of equality of error variances is significant. This means that if the univariate  $F$  tests for these variables are also significant, then we will need to interpret this finding at a more conservative  $\alpha$  level, which is what has been adopted in the study.

*Student gender.* This section reports results on the MANOVA conducted on the five components (i.e., values) by *gender*. Eight hundred and eleven students (348 boys and 463 girls) declared their gender and completed all items. Using an  $\alpha$  level of .05, we see that Pillai's Trace criterion is significant. This significant  $F$  indicates that there are significant differences between the gender groups on a linear combination of the dependent variables.

Since the multivariate effect for student gender is significant ( $p < .05$ ), any interpretation of the univariate between-subjects effects should be adjusted for family-wise or experiment-wise error using a Bonferroni-type adjustment, with an adjusted  $\alpha$  of  $.05/5 = .01$ . As a result, we have significant univariate main effects for:

- *Connections* (C2):  $F(1, 799) = 10.780, p < .01, \eta^2 = .013$ .

In other words, we can say that Korean male and female students value *connections* differently.

*School system.* This section reports results on the MANOVA conducted on the five components by school system (i.e., primary vs. secondary schools). Eight hundred and eleven students (407 from primary schools and 404 from secondary schools) completed all items.

Pillai's Trace criterion showed that there are significant group differences on a linear combination of the dependent variables. Since the multivariate effect for school system is significant ( $p < .05$ ), any interpretation of the univariate between-subjects effects should be adjusted for family-wise or experiment-wise error using a Bonferroni-type adjustment, with an adjusted  $\alpha$  of  $.05/5 = .01$ . As a result, we have significant univariate main effects for the following four values:

- *Connections* (C2):  $F(1, 799) = 14.464, p < .01, \eta^2 = .018$ ;
- *Fun* (C3):  $F(1, 799) = 33.625, p < .01, \eta^2 = .040$ ;

- *Accuracy* (C5):  $F(1, 799) = 12.007, p < .01, \eta^2 = .015$ ;
- *Efficiency* (C7):  $F(1, 799) = 7.044, p < .01, \eta^2 = .009$ .

On the whole, then, Korean students' valuing of *connections*, *fun*, *accuracy*, and *efficiency* are impacted upon by whether they were currently in primary or secondary school education.

*Student confidence.* This section reports the results of the MANOVA conducted on the five components by student confidence. This variable was measured through students' response to the 5-choice Likert-type scale item, "I do well in mathematics at school." Eight hundred and eleven students completed all items. The 485 students (i.e., 59.8%) who indicated either "strongly agree" or "agree" were regarded as belonging to the *confident* group; the 137 students (i.e., 16.9%) who checked either "strongly disagree" or "disagree" were regarded as part of the *not confident* group; and the rest of the students (189 of them, 23.3%) who checked "not sure" were regarded as *unsure* group of their mathematics performance.

Pillai's Trace criterion was used to test whether there is any significant group difference on a linear combination of the dependent variables. Since the multivariate effect for student confidence is significant ( $p < .05$ ), we have to interpret the univariate between-subjects effects by adjusting for family-wise or experiment-wise error using a Bonferroni-type adjustment, and we derive the adjusted  $\alpha$  level .01 (i.e., .05/5). Using this  $\alpha$  level, we have significant univariate main effects for the following two variables:

- *Understanding* (C1):  $F(2, 799) = 11.747, p < .01, \eta^2 = .029$ ;
- *Connections* (C2):  $F(2, 799) = 8.923, p < .01, \eta^2 = .022$ .

Thus, the extent to which students in Korea were confident about their own mathematics performance affected their valuing of *understanding* and *connections*.

## Discussion

This research, part of the wider WIFI study, investigates what students find important in their respective mathematics learning experiences. Even though there are research limitations (e.g., assessing only espoused values rather than enacted values) of identifying students' values through the survey methods such as the questionnaire (Chan & Wong, 2019; Seah et al., 2017), the intention of the Korean participation has been to shed light on the paradox of how Korean students perform excellently in international mathematics assessment exercises such as PISA, when they are known to be experiencing negative affect with regard to mathematics learning.

The analysis of the WIFI questionnaire data shows that Korean students value *understanding* (C1), *connections* (C2), *fun* (C3), *accuracy* (C5), and *efficiency* (C7) in their mathematics learning. Multivariate analysis of variance further shows that there is significant gender difference in the



ways Korean students value *connections*. On the other hand, the students' valuing of *connections*, *fun*, *accuracy*, and *efficiency* was mediated by school type, namely, primary and secondary schools. The degree of student confidence in doing mathematics also affected how *understanding* and *connections* were valued.

A consideration of the five attributes of mathematics learning that Korean students value suggests that the focus is pretty much broad-based. The valuing of *understanding* (and *connections*) is balanced by a valuing also of *performance*, through the importance placed on *accuracy* and *efficiency*. This provides an example of how these valuing might co-exist and complement each other, given that deeper understanding may lead to enhanced performance.

Yet, the dominant valuing of *understanding*, followed by *connections*, among Korean students suggests that their sustained high performance in PISA assessments are possibly underpinned by deep and meaningful learning, which is demonstrated by the country's third and second placing for Year 4 and Year 8 students respectively in the latest TIMSS exercise, and by similar stellar performance in previous cycles. These two values are related, in that "the degree of understanding is determined by the number and strength of the connections" (Hiebert & Carpenter, 1992, p. 67). Together, they relate to a powerful type of understanding, which facilitates transfer of knowledge and skills learnt to applications and creative work, and in this sense, provides an explanation to why Korean students have been outperforming their peers in different types of mathematics assessment exercises.

Furthermore, even though Korean students generally possess negative affect toward their learning of mathematics, this does not mean that they neglected the subject and gave it less emphasis. In fact, the students' valuing of such values as *understanding* and *connections* suggests that the students are prepared to engage with intrinsic values, which arguably represents the valuing which educators hope to develop among (mathematics) learners. This is reflected, for example, in the recent curricular reforms in Korea. To deal with educational and social issues associated with students who give up mathematics from the early days of primary school, school mathematics content has been reduced for students to promote conceptual understanding of essential mathematics at each school level (MOE, 2015; Pang, 2014). Moreover, various approaches were made for students to appreciate the usefulness of mathematics by connecting it to other subjects or to real-life contexts and, in so doing, fostering positive student attitude (NASEM, 2015). These efforts have been made not only in developing the national mathematics curriculum or its concomitant curricular materials but also in implementing them in the actual classroom. Among them, a noticeable change is to emphasize process-oriented assessment (e.g., explaining how one solves a given problem in each lesson) instead of outcome-oriented evaluation (e.g., getting high scores after finishing one unit of mathematics), specifically both in primary and middle schools.

Male and female students in Korea appeared to be valuing *connections* differently. Differential valuing of *connections* may be related to how different genders emphasize the utilitarian nature and/or role of mathematics in one's life, relating perhaps to prior observations that males are inclined more to adopt utilitarian reasoning (Friesdorf et al., 2015). This may be related to and reflected in the minor differences in mathematics performance between Korean boys and girls, specifically in the series of PISA (OECD, 2016, 2019b). At best minor gender difference is likely to provide further support to the proposal earlier that the attributes which Korean students (both boys and girls) value in mathematics pedagogy are related to understanding the content, rather than to achieving high marks in assessment tasks.

The extent to which *connections*, *fun*, *accuracy*, and *efficiency* are valued by Korean students is also observed to be influenced by school levels. A possible explanation of the different valuing of these four values by school levels may be related to the pressures that Korean students in secondary schools are feeling from high stakes assessments which they are increasingly being introduced to, in which time limits make many people believe that getting the right answers would secure full marks for the assessment items involved. It is not clear, however, if a greater variety of values are being espoused in secondary mathematics classrooms, if valuing is less explicit in these classrooms, or if secondary school students do not perceive values as readily as their younger peers in primary schools. Further research investigating possible reasons for this observed difference across school systems is certainly encouraged.

The students' confidence in their own mathematics performance also affects the extent to which *understanding* and *connections* are embraced by the students. Despite the outstanding performance in mathematics of Korean students, the lowest confidence in mathematics has been repeatedly reported. For instance, in TIMSS 2015 (Mullis et al., 2016) only 64% of the Korean fourth graders were either very confident or confident in mathematics, while the OECD average was 77% (cf., 46% vs. 57% for eighth graders). In a similar vein, only about 59.8% of the students in this study (i.e., 485 of 811 students) agreed or very much agreed that they were doing well at mathematics learning. In other words, students' affective variables, including confidence specifically here, do not have a direct relationship to their performance. This thus might be a reminder to teachers that the many affective variables (e.g., satisfaction, attitudes, beliefs, efficacy, and confidence) do operate and interact in complex ways, so that correlations and relationships among these variables cannot be assumed in any intuitive manner. Further research on the nature of relationships among affective variables would shed light on this aspect of (mathematics) pedagogy. On the other hand, the dominant valuing of *understanding* and *connections* by the confident group may be a reasonable explanation for outstanding performance. This may support our earlier stance with which we differentiate values and valuing from the affect domain.

Another notable feature in this study is that the students' valuing of *connections* is found to be regulated by student gender, school level, and students' confidence level. For all the importance and significance of mathematical connections that we know in both curriculum planning and education research, a recent preliminary search through curriculum documents and research databases failed to produce any mention of how we can facilitate the valuing of *connections* among different individuals who are the students. The various publications and readings painted a picture that mathematical connections are important for mathematics learning, and that all students need to—and can—be taught it. That is, activities provided in current policies and research suggest that they can be implemented to all students without any mention of any need for differentiation. This approach may need to be reviewed, in light of our findings in the Korean sample.

How do all these help us understand how “negative” affect in Korea still leads to high performance? Like students of other East Asian countries, Korean students are often reported to perceive the external value of mathematics well (e.g., you need to be good at mathematics to have a good job). Similarly, the cultural demands in the Korean society—not least of which are ones which are Confucian in heritage and nature—of the need for students to do well in high-stakes assessments such as college entrance examinations play a role to have willingness to attain high performance. Still the five values identified through this study may provide us with another explanation. All of them are mathematics educational in nature (Bishop, 1988). The top two values, namely *understanding* and *connections*, complement and support two of the other three attributes, that is, *accuracy* and *efficiency*, which together explain to a great extent why Korean students can still achieve high mathematical performance, even though they may not like mathematics and/or doing mathematics.

Yet the findings of this study also highlight the significance and strength of conation (represented by the valuing, see Seah, 2019) in neutralizing any damaging effect of negative affect. It seems that with the “right” kinds of enabling values, the will and motivation that come with the valuing can override the functions of reasoning and of feeling. This motivation will provide the driving force for the individual to achieve and thrive in the attributes that are being valued, even in the face of obstacles or difficulties. We acknowledge that research into this area which brings together cognition, affect, and conation is much needed, to help us better understand how these facets of the human mind interact with one another and work together, possibly orchestrated and dominated by conative variables such as motivation and valuing.

The conduct of this study and the dissemination of the findings here by no means suggest that students' emotions (with regard to mathematics and mathematics learning) can be ignored. There is certainly value for fostering positive and supporting affect among mathematics students, with benefits that extend beyond mathematics performance. The affective objective of promoting

students' positive attitude toward mathematics learning was even introduced in one of the recent mathematics curriculum reforms (NASEM, 2015; Pang, 2014). That said, this study also acknowledges that for one reason or another, there can always be students who do not like mathematics, or who do not feel confident of their own capabilities in the subject. Korea remains at the bottom of affective rankings in TIMSS and PISA (Mullis et al., 2016; OECD, 2017, 2019b). In such a scenario then, how might an understanding and/or developing of what students value in mathematics learning support students' affective development and cognitive growth, thus breaking the low affect—high achievement cycle/paradox we observe in Korea?

### Acknowledgements

We would like to thank SooYun Cho, Jin Sunwoo, and Seungmin Kim for their assistance in data collection or discussions of the values corresponding to the items of the WIFI questionnaire from the Korean perspective.

### Contributorship

JeongSuk Pang was responsible for writing the paper and responding to reviewers' comments. She collected the Korean data of the WIFI study, designed a value coding method during the data analysis phase, and interpreted the various results of the study tailored to the Korean context. Wee Tiong Seah as the main investigator of the WIFI study developed the "valuing in mathematics education" framework and took charge of quantitative analysis (i.e. principal component analysis and multivariate analysis of variance) of the WIFI questionnaire data.

### Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

### References

- Biggs, J. (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. 45–68). Comparative Education Research Centre/The Australian Council for Educational Research.
- Bishop, A. J. (1988). *Mathematical enculturation: A cultural perspective on mathematics education*. Kluwer.
- Bishop, A. J. (1996). *How should mathematics teaching in modern societies relate to cultural values—Some preliminary questions* [Paper presentation]. Seventh Southeast Asian conference on Mathematics Education, Hanoi, Vietnam.
- Bishop, A. J. (2014). Values in mathematics education. In S. Lerman (Ed.), *Encyclopedia of mathematics education* (pp. 633–636). Springer.
- Chan, Y.-C., & Wong, N.-Y. (2019). Methodological issues in the investigation of values in mathematics. In P. Clarkson, W. T. Seah, & J. Pang (Eds.), *Values and valuing in mathematics education: Scanning and scoping the territory* (pp. 197–208). Springer.

- Clarkson, P., Bishop, A., Seah, W. T., & FitzSimons, G. (2000, December). *Methodology challenges and constraints in the values and mathematics project*. [Paper presentation]. Annual Meeting of the Australian Association for Research in Education, Sydney, Australia.
- Clarkson, P., Seah, W. T., & Pang, J. (Eds.). (2019). *Values and valuing in mathematics education: Scanning and scoping the territory*. Springer.
- Friedsdorf, R., Conway, P., & Gawronski, B. (2015). Gender differences in responses to moral dilemmas: A process dissociation analysis. *Personality and Social Psychology Bulletin*, 41(5), 696–713.
- Hannula, M. S. (2012). Looking at the third wave from the West: Framing values within a broader scope of affective traits. *ZDM*, 44(1), 83–90.
- Hiebert, J., & Carpenter, T. P. (1992). Learning and teaching with understanding. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 65–97). Mcmillan.
- Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). *Cultures and organizations: Software of the mind* (3rd ed.). McGraw-Hill.
- Johnson, B., & Christensen, L. (2010). *Educational research: Quantitative, qualitative, and mixed approaches*. SAGE.
- Keitel, C. (2003). *Values in mathematics classroom practice: The students' perspective*. [Paper presentation]. Conference of the Learners' Perspective Study international research team, Melbourne, Australia.
- King, R. B., & Bernardo, A. B. I. (Eds.). (2016). *The psychology of Asian learners: A festschrift in honor of David Watkins*. Springer.
- Leung, F. K. S. (2001). In search of an East Asian identity in mathematics education. *Educational Studies in Mathematics*, 47, 35–51.
- Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education*, 28(1), 26–47.
- Ministry of Education of Korea [MOE]. (2015). *Mathematics curriculum* (in Korean). <https://kofac.re.kr/web/contents/resultBoard.do?schM=view&id=16905>
- Mok, I. A. C. (2007). Shedding light on the East Asian learner paradox: Reconstructing student-centredness in a Shanghai classroom. *Asia Pacific Journal of Education*, 26(2), 131–142.
- Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 international results in mathematics*. <http://timssandpirls.bc.edu/timss2015/international-results/>
- National Academies of Sciences, Engineering, and Medicine [NASEM]. (2015). *Mathematics curriculum, teacher professionalism, and supporting policies in Korea and the United States: Summary of a workshop*. The National Academies Press. <https://doi.org/10.17226/21753>
- Organisation for Economic Co-operation and Development [OECD]. (2016). *PISA 2015 results (Volume 1): Excellence and equity in education*. <https://doi.org/10.1787/9789264266490-en>
- OECD. (2017). *PISA 2015 results (Volume III): Students' well-being*. <http://dx.doi.org/10.1787/9789264273856-en>
- OECD. (2019a). *PISA 2018 results (Volume 1): What students know and can do*. <https://doi.org/10.1787/5f07c754-en>
- OECD. (2019b). *Country note (Korea): PISA 2018 results*. [http://www.oecd.org/pisa/publications/PISA2018\\_CN\\_KOR.pdf](http://www.oecd.org/pisa/publications/PISA2018_CN_KOR.pdf)

- Pang, J. (2014). Changes to the Korean mathematics curriculum: Expectations and challenges. In Y. Li & G. Lappan (Eds.), *Mathematics curriculum in school education* (pp. 261–277). Springer.
- Park, H. (2008). Inequality of educational opportunity in Korea by gender, socio-economic background, and family structure. In P. C. W. Chan (Ed.), *Equality in Asia-Pacific: Reality or a contradiction in terms?* (pp. 182–200). Routledge.
- Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 257–315). Information Age.
- Raths, L. E., Harmin, M., & Simon, S. B. (1987). Selections from values and teaching. In J. Carbone (Ed.), *Value theory and education* (pp. 198–214). Robert E. Krieger.
- Reichers, A. E., & Schneider, B. (1990). Climate and culture: An evolution of constructs. In B. Schneider (Ed.), *Organizational climate and culture* (pp. 5–39). Jossey-Bass.
- Rokeach, M. (1973). *The nature of human values*. The Free Press.
- Seah, W. T. (1999). Values in Singapore and Victoria lower secondary mathematics textbooks: A preliminary study. In Y. P. Leong & M. A. K. Clements (Eds.), *Proceedings of the fourth annual conference of the Department of Science and Mathematics Education: Cultural and language aspects of science, mathematics, and technical education* (pp. 389–398). Universiti Brunei Darussalam.
- Seah, W. T. (2019). Values in mathematics education: Its conative nature, and how it can be developed. *Research in Mathematical Education*, 22(2), 99–121.
- Seah, W. T., & Andersson, A. (2015). Valuing diversity in mathematics pedagogy through the volitional nature and alignment of values. In A. Bishop, H. Tan, & T. Barkatsas (Eds.), *Diversity in mathematics education: Towards inclusive practices* (pp. 167–183). Springer.
- Seah, W. T., Baba, T., & Zhang, Q. (2017). The WIFI study: Students' valuing of mathematics learning in Hong Kong and Japan. In J. W. Son, T. Watanabe, & J. J. Lo (Eds.), *What matters? Research trends in international comparative studies in mathematics education* (pp. 333–354). Springer.
- Senge, P., Kleiner, A., Roberts, C., Ross, R., & Smith, J. (1994). *The fifth discipline fieldbook: Strategies and tools for building a learning organisation*. Crown.
- Shang, J., Fu, Q., Dienes, Z., Shao, C., & Fu, X. (2013). Negative affect reduces performance in implicit sequence learning. *PLoS ONE*, 8(1), e54693. <https://doi.org/10.1371/journal.pone.0054693>
- Tan, S. F., & Lim, C. S. (2013). Effective mathematics lesson from the eyes of primary pupils. In M. Inprasitha (Ed.), *Proceedings of the sixth East Asia regional conference on mathematics education* (Vol. 2, pp. 184–193). Centre for Research in Mathematics Education.
- Victorian Curriculum and Assessment Authority [VCAA]. (2017). *The Victorian curriculum F-10: Mathematics*. Victorian Curriculum and Assessment Authority.
- 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.