# MATHEMATICS LEARNING IN MAINLAND CHINA, HONG KONG AND TAIWAN: THE VALUES PERSPECTIVE

Wee Tiong Seah[1], Qiaoping Zhang[2], Tasos Barkatsas[3], Huk Yuen Law[2], Yuh-Chyn Leu[4]

[1]Monash University, Australia, [2]Chinese University of Hong Kong, [3]RMIT University, Australia, [4]National Taipei Teachers College, Taiwan

*Drawing on 1386 questionnaire responses, 11- and 12-year old primary students in mainland China, Hong Kong, and Taiwan valued the same six orientations in their mathematics learning. These are achievement, relevance, practice, communication, information and communication technologies [ICT], and feedback. Each of these six values was also embraced to different degrees by students across the three regions. These findings shed light on how students' values might be used to support learning, at the same time emphasising that such values are culture-dependent.*

## INTRODUCTION

Students from several East Asian nations have been consistently performing very well in international comparative tests such as Programme for International Student Assessment [PISA] and Trends in International Mathematics and Science Studies [TIMSS]. These include regions such as Shanghai, Hong Kong, Japan, Korea, Singapore, and Taiwan (Mullis, Martin, Foy & Arora, 2012; OECD, 2013). Given that different cultures (or education systems) embrace and emphasise different approaches to mathematics teaching (Atweh & Seah, 2008), cultural values regarding (mathematics) education constitute a key factor for the students' performance in these international comparative tests (Leung, 2006). A Nuffield Foundation review had found that "high attainment may be much more closely linked to cultural values than to specific mathematics teaching practices" (Askew, Hodgen, Hossain, & Bretscher, 2010, p. 12).

Looking beyond the general characteristics of East Asian nations and the constituent Confucian Heritage Cultures, important differences exist amongst these various education systems. How might these differences affect the people's lifestyles, their outlooks, as well as their views on formal education?

In this light, this paper reports on the analysis of data collected from 11- and 12-year old primary students in mainland China, Hong Kong, and Taiwan which relate to what they value in mathematics learning. These three regions are located close to one another geographically, and most of their populations share the same ethnic roots (i.e. Han Chinese). What do these students value collectively in mathematics learning? To what extent are these valued similarly or differently across each of the three regions?

We will first review generally the recent historical developments across mainland China, Hong Kong and Taiwan. Given that the research being reported here is part of a

2014. In Nicol, C., Oesterle, S., Liljedahl, P., & Allan, D. (Eds.) Proceedings of the Joint Meeting of PME 38 and PME-NA 36,Vol. 5, pp. 145-152. Vancouver, Canada: PME.

wider study, this paper will then provide an outline of the background to the study. The quantitative data collected will also be presented, and the findings summarised.

## HISTORICAL CONTEXTS OF THE THREE REGIONS

After the Communist party took over mainland China in 1949, the country's education system became very much influenced by that being used in the Soviet Union. Basic computation skills and 'traditional' topics (e.g. Euclidean geometry) were emphasised. The Modern Mathematics movement did not appear to have created any influence on the Chinese mathematics education system. It was not until the mid-1980s when mainland China adopted the open door economic policy that educational ideas from overseas – and from the Western countries in particular – were accepted. School education became available to the general mass of the Chinese population only in the early 2000s.

In those early days, Western missionaries were refused entry to mainland China. They spent their time in Hong Kong instead and established schools there. As a British colony too, the Hong Kong school education system had been British. These had facilitated the introduction into the education system of initiatives stimulated by Nuffield Mathematics and Modern Mathematics. Universal education was implemented in the late 1970s (Wong & Tang, 2012).

Taiwan developed somewhat differently from mainland China after 1949. Since the Nationalist government was set up in Taiwan that year, Taiwan has been in touch with the Western world. Educational ideas from around the world – especially the United States and Japan – were imported. Universal education was implemented in 1968. The Modern Mathematics movement did influence Taiwan and was introduced into the mathematics curriculum around that time.

Recently, in revising their respective mathematics education curricula, mainland China, Hong Kong and Taiwan joined many other education systems around the world in embracing higher order thinking abilities such as collaboration, communication and creativity (Wong, Han, & Lee, 2004). It is in this context that we investigated what students from each of these three regions value in their mathematics learning experiences, and how similar/different these are.

## CONTEXTUALISING THIS STUDY

The data reported in this paper were collected for a larger-scale, '**W**hat **I** **F**ind **I**mportant (in mathematics education)' [**WIFI**] study. For us,

> values are the convictions which an individual has internalised as being the things of importance and worth. What an individual values defines for her/him a window through which s/he views the world around her/him. Valuing provides the individual with the will and determination to maintain any course of action chosen in the learning and teaching of mathematics. They regulate the ways in which a learner's/teacher's cognitive skills and emotional dispositions are aligned to learning/teaching. (Seah & Andersson, in press)

The study reported in this paper poses the following research questions:

1. What do primary school students in mainland China, Hong Kong and Taiwan value with regards to mathematics and to mathematics learning?
2. How do primary school students in mainland China, Hong Kong and Taiwan value these aspects of mathematics and mathematics education similarly and differently?

## METHODOLOGY

The questionnaire method had been selected, given its appropriateness in values research (Johnson & Christiensen, 2010; Reichers & Schneider, 1990).

The WIFI questionnaire is a 93-item instrument with a combination of 64 Likert-scale items, 10 slider rating scale items, 6 open-ended items, and 13 items which collect demographic information about the respondents. The 74 Likert-scale and slider rating scale items name a list of mathematics learning tasks which reflect Bishop's (1988) 6 mathematical values, 14 mathematics educational values that were identified in a previous Third Wave Project's study (see, for example, Seah & Peng, 2012), and Hofstede's (1997) 6 value continua. The open-ended items include hypothetical situations for students to respond to.

For this paper, only the first section of 64 Likert-scale items of the WIFI questionnaire was analysed. Also, only the responses of the 11- and 12-year old primary school students were selected, even though the same questionnaire was administered to 3814 students in primary and secondary schools in urban areas across the three regions. This translated to a total of 1386 students from Wuhan (mainland China), Hong Kong, and Taipei (Taiwan). The 11- and 12-year old students (typically in the final two years of their primary school education) in the participating schools were invited to take part in the anonymous survey exercise during class time.

## RESULTS

### What students valued

A Principal Component Analysis [PCA] with a Varimax rotation was used to examine the 64 questionnaire items. The significance level was set at 0.05, while a cut-off criterion for component loadings of at least 0.45 was used in interpreting the solution. Items that did not meet the criteria were eliminated.

The Kaiser-Meyer-Olkin [KMO] (Kaiser, 1970) measure of sampling adequacy was 0.96 and Bartlett's test of sphericity [BTS] (Bartlett, 1950) was significant at the 0.001 level. The factorability of the correlation matrix was thus assumed, which demonstrated that the identity matrix instrument was reliable and confirmed the usefulness of the factor analysis. According to the cut-off criterion, 17 items were removed from the original 64. The analysis yielded six components (see Table 1) with eigenvalues greater than one, which accounted for 45.65% of the total variance.

| | Component | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Q58KnowingWhichFormulaToUse | .706 | | | | | |
| Q56KnowingTheStepsOfTheSolution | .678 | | | | | |
| Q54UnderstandingConceptsProcesses | .637 | | | | | |
| Q13PractisingHowToUseMathsFormulae | .623 | | | | | |
| Q14MemorisingFacts | .615 | | | | | |
| Q63UnderstandingWhyMySolutionIsIncorrectOrCorrect | .606 | | | | | |
| Q59KnowingTheTheoreticalAspectsOfMathematics | .577 | | | | | |
| Q32UsingMathematicalWords | .568 | | | | | |
| Q49ExamplesToHelpMeUnderstand | .536 | | | | | |
| Q38GivenAFormulaToUse | .531 | | | | | |
| Q15LookingForDifferentWaysToFindTheAnswer | .522 | | | | | |
| Q30AlternativeSolutions | .514 | | | | | |
| Q33WritingTheSolutionsStepbystep | .513 | | | | | |
| Q55ShortcutsToSolvingAProblem | .504 | | | | | |
| Q28KnowingTheTimesTables | .475 | | | | | |
| Q5ExplainingByTheTeacher | .473 | | | | | |
| Q2Problemsolving | .473 | | | | | |
| Q61StoriesAboutMathematicians | | .649 | | | | |
| Q18StoriesAboutRecentDevelopmentsInMathematics | | .640 | | | | |
| Q17StoriesAboutMathematics | | .630 | | | | |
| Q21StudentsPosingMathsProblems | | .613 | | | | |
| Q11AppreciatingTheBeautyOfMathematics | | .590 | | | | |
| Q60MysteryOfMaths | | .586 | | | | |
| Q39LookingOutForMathsInRealLife | | .566 | | | | |
| Q20MathematicsPuzzles | | .552 | | | | |
| Q52HandsonActivities | | .545 | | | | |
| Q29MakingUpMyOwnMathsQuestions | | .524 | | | | |
| Q34OutdoorMathematicsActivities | | .522 | | | | |
| Q40ExplainingWhereTheRulesFormulaeCameFrom | | .506 | | | | |
| Q12ConnectingMathsToRealLife | | .491 | | | | |
| Q47UsingDiagramsToUnderstandMaths | | .480 | | | | |
| Q25MathematicsGames | | .473 | | | | |
| Q19ExplainingMySolutionsToTheClass | | .451 | | | | |
| Q36PractisingWithLotsOfQuestions | | | .791 | | | |
| Q37DoingALotOfMathematicsWork | | | .751 | | | |
| Q57MathematicsHomework | | | .699 | | | |
| Q62CompletingMathematicsWork | | | .600 | | | |
| Q43MathematicsTestsExaminations | | | .597 | | | |
| Q7WholeclassDiscussions | | | | .702 | | |
| Q3SmallgroupDiscussions | | | | .581 | | |
| Q10RelatingMathematicsToOtherSubjectsInSchool | | | | .454 | | |
| Q23LearningMathsWithTheComputer | | | | | .789 | |
| Q24LearningMathsWithTheInternet | | | | | .777 | |
| Q22UsingTheCalculatorToCheckTheAnswer | | | | | .760 | |
| Q4UsingTheCalculatorToCalculate | | | | | .673 | |
| Q44FeedbackFromMyTeacher | | | | | | .726 |
| Q45FeedbackFromMyFriends | | | | | | .725 |

Note. Extraction method: PCA; Rotation method: Varimax with Kaiser Normalization, Minimum factor loadings .45; KMO, MSA, Eigenvalues > 1.

Table 1: Rotated component matrix.

We named the six components of the students' set of values as follows: *achievement*, *relevance*, *practice*, *communication*, *ICT*, and *feedback*.

**Regional differences amongst the student values**

To answer research question (2), a comparison was made of the mean responses for each component for each region. This showed that the structure of the values dimensions was very similar across the regions (see Table 2). (Note that in the questionnaire, a value with a higher mean score means that the items making up the component were considered more unimportant by the students.)

| Component | Region | | | F test | Effect size |
|---|---|---|---|---|---|
| | CHN | HKG | TWN | | |
| | M(SD) | M(SD) | M(SD) | | |
| *Achievement (C1)* | 1.44(.37) | 1.51(.52) | 1.64(.51) | 8.045 $p < 0.001$ | $\eta 2 = 0.012$; TWN > CHN |
| *Relevance (C2)* | 1.79(.51) | 2.04(.62) | 2.23(.74) | 78.078 $p < 0.001$ | $\eta 2 = 0.102$; TWN> HKG, CHN; HKG > CHN |
| *Practice (C3)* | 1.72(.62) | 1.98(.83) | 2.07(.78) | 8.412 $p < 0.001$ | $\eta 2 = 0.012$; HKG, TWN > CHN |
| *Communication (C4)* | 1.95(.75) | 2.25(.75) | 1.94(.72) | 49.140 $p < 0.001$ | $\eta 2 = 0.067$; HKG > TWN, CHN |
| *ICT (C5)* | 3.09(.77) | 2.69(.93) | 3.14(.88) | 18.082 $p < 0.001$ | $\eta 2 = 0.026$; TWN, CHN > HKG |
| *Feedback (C6)* | 1.93(.95) | 1.92(.82) | 2.06(1.0) | 13.877 $p < 0.001$ | $\eta 2 = 0.020$; TWN > HKG |

Note: CHN: Mainland China; HKG: Hong Kong; TWN: Taiwan.

Table 2: Mean comparison among three regions for the six components.

The primary students from each of the three regions valued the same six convictions most. In fact, all of them also valued *achievement* most, since the mean scores of *achievement* (*C1*) in mainland China, Hong Kong and Taiwan (1.44, 1.51, and 1.64 respectively) were the lowest compared to the other five components. *ICT* (*C5*), on the other hand, was valued least by students in all three regions, compared to the other five components. The mean scores were 3.09, 2.69 and 3.14 respectively. However, some differences were identified on closer examination of the results for each region, specifically by examining the sequencing of the mean scores. For mainland China, the sequence of mean scores from lowest to highest was C1-C3-C2-C6-C4-C5. In Hong Kong, the sequence was C1-C6-C3-C2-C4-C5; for Taiwan, it was C1-C4-C6-C3-C2-C5.

A multivariate analysis of variance (MANOVA) with Tukey's HSD Post Hoc multiple comparisons tests was conducted to explore cultural differences for each value dimension by region. We had significant univariate main effects for each of the components at the 0.001 alpha level. There were statistically significant differences amongst the students by region, such that:

- Students in mainland China (CHN) valued *achievement* more than their peers in Hong Kong (HKG) and Taiwan (TWN).
- Students in CHN valued *relevance* more than their peers in HKG, who in turn valued *relevance* more than those in TWN.
- Students in CHN valued *practice* more than those in HKG and TWN
- Students in TWN and CHN valued *communication* more than their peers in HKG
- Students in HKG valued *ICT* more than those in CHN and TWN.
- Students in HKG valued *feedback* more than their peers in TWN.

## DISCUSSION

### What were valued commonly across the three regions

The WIFI questionnaire was used to identify the value structure of East Asian students in mainland China, Hong Kong and Taiwan. The 1386 11- and 12-year old primary students in these three education systems valued six orientations commonly. These were, in order of importance, *achievement, relevance, practice, communication, ICT*, and *feedback.*

The valuing of *achievement* was the most important to the primary students. *Practice* appeared to be emphasised as a means of doing well in mathematics. The *relevance* of the learning experience was also highly regarded, including its use in daily life and hands-on experience. Students also valued ideas such as *ICT* and *communication* which were advocated in the mathematics curriculum reforms in these regions (and elsewhere). Finally, *feedback* about their learning was highly valued, reflecting the findings of prior studies on students' preferred mathematics learning environment (Ding & Wong, 2012).

The students placed most importance in the valuing of *achievement* in their mathematics learning experience, a cultural trait that has been associated with the ethnic Chinese (see, for example, Bond, 2010). The questionnaire items in this component include knowing, memorizing and using mathematical facts and formulae, emphasizing solutions and seeking different ways to solve problems. On the one hand, this reflects the high value that the ethnic Chinese students place on basic skills. On the other hand, however, when this valuing is considered in the context of the Chinese culture, in which success is often attributed with the efforts made, we can understand how it can create tremendous pressure on the students. This can also be intensified when the students view learning as an obligation, to repay the care given to them by their parents (Wong, 2004). In addition, when the 'basics' progress from computation to other higher order thinking skills, there is a danger that the students will interpret 'memorizing facts' as 'memorizing hands-on skills' and 'memorizing problem solving routines' as well (Wong, Han, & Lee, 2004).

These findings contribute to current knowledge that can further improve our practices in mathematics teaching. It is often suggested that congruence between the students' preferences and the perceived classroom environment is an influential factor for better learning (Fraser, 1998), and current research relating to values alignment reflect this (see Seah & Andersson, in press).

## Cross-regional differences

Although each region valued *achievement* most and *ICT* least (comparatively) amongst the six top values, the order of valuing for the other four common top orientations was different in each region.

Statistically significant differences exist amongst the three regions for each of the 6 values. *Achievement*, *relevance* and *practice*, which are closely tied to examinations, were more salient in student values in mainland China. Students in Hong Kong valued *relevance*, *ICT* and *feedback* more than their peers in Taiwan and mainland China, who valued *communication* more than students in Hong Kong. These differences, no matter how subtle they are, show that values are culture dependent. Thus, even if what students in East Asia value might be unique to the area, there can be diversity of value priorities within the area too.

## References


Askew, M., Hodgen, J., Hossain, S., & Bretscher, N. (2010). *Values and variables: Mathematics education in high-performing countries*. London: Nuffield Foundation.

Atweh, B., & Seah, W. (2008). *Theorising values and their study in mathematics education*. Paper presented at the Australian Association for Research in Education Conference, Fremantle, Australia.

Bartlett, M. S. (1950). Tests of significance in factor analysis. *British Journal of Psychology*, *3*, 77-85.

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

Bond, M. H. (Ed.). (2010). *The Oxford handbook of Chinese psychology*. New York: Oxford University Press.

Ding, R., & Wong, N. Y. (2012). The learning environment in the Chinese mathematics classroom. In Y. Li & R. Huang (Eds.), *How Chinese teach mathematics and improve teaching* (pp. 150-164). New York: Routledge.

Fraser, B. J. (1998). Science learning environment: Assessment, effect and determinants. In B. J. Fraser & K. G. Tobin (Eds.), *The international handbook of science education* (pp. 527-564). Dordrecht, The Netherlands: Kluwer.

Hofstede, G. (1997). *Cultures and organizations: Software of the mind* (Revised ed.). New York: McGraw-Hill.

Johnson, B., & Christensen, L. (2010). *Educational research: Quantitative, qualitative, and mixed approaches*. Boston, MA: SAGE Publishers.

Kaiser, H. F. (1970). A second generation little Jiffy. *Psychometrika*, *35*, 401-416.

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. 21-46). New York: Springer.

Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in Mathematics*. Amsterdam, The Netherlands: International Association for the Evaluation of Educational Achievement (IEA).

OECD. (2013). *PISA 2012 Results: What students know and can do – Student performance in mathematics, reading and science* (Vol. 1). Paris: PISA, OECD.

Reichers, A. E., & Schneider, B. (1990). Climate and culture: An evolution of constructs. In B. Schneider (Ed.), *Organizational climate and culture*. San Francisco, CA: Jossey-Bass.

Seah, W. T., & Andersson, A. (in press). Valuing diversity in mathematics pedagogy through the volitional nature and alignment of values. In A. Bishop, T. Barkatsas, & H. Tan (Eds.), *Rethinking diversity in mathematics education: Towards inclusive practices*. New York: Springer.

Seah, W. T., & Peng, A. (2012). What students outside Asia value in effective mathematics lessons: A scoping study. *ZDM: The International Journal on Mathematics Education*, *44*, 71-82. doi: DOI 10.1007/s11858-012-0398-x

Wong, N. Y. (2004). The CHC learner's phenomenon: Its implications on mathematics education. In L. Fan, N. Y. Wong, J. Cai, & S. Li (Eds.), *How Chinese learn mathematics: Perspectives from insiders* (pp. 503-534). Singapore: World Scientific.

Wong, N. Y., Han, J. W., & Lee, P. Y. (2004). The mathematics curriculum: Towards globalisation or Westernisation? In L. Fan, N. Y. Wong, J. Cai, & S. Li (Eds.), *How Chinese learn mathematics: Perspectives from insiders* (pp. 27-70). Singapore: World Scientific.

Wong, N. Y., & Tang, K. C. (2012). Mathematics education in Hong Kong under colonial rule. *BSHM Bulletin: Journal of the British Society for the History of Mathematics*, *27*, 119-125.