International Journal on Emerging Mathematics Education
Vol. 3, No. 1, March 2019, pp. 41-56
P-ISSN: 2549-4996, E-ISSN: 2548-5806, DOI: http://dx.doi.org/10.12928/ijeme.v3i1.11648

The Valuing of Mathematics Learning in Schools: A Gendered Perspective

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Abstract

In this article, gender differences in the valuing of mathematics by Hong Kong primary and secondary students have been investigated. The participants were 1081 upper primary school (Grades 5 and 6) and secondary school (Grades 8 and 9) students from various metropolitan Hong Kong schools. An Analysis of Variance (ANOVA) was conducted to investigate the existence of gender differences on a number of values components. Statistically significant differences between boys' and girls' valuing of mathematics learning were found on three of the nine components derived via a Principal Component Analysis (PCA).

Keywords: Asian learners, gender, Hong Kong, culture, values

How to Cite: Barkatsas, T., Law, H.Y., Seah, W.T., & Wong, N.Y. (2019). The Valuing of Mathematics Learning in Schools: A Gendered Perspective. *International Journal on Emerging Mathematics Education, 3*(1), 41-56. http://dx.doi.org/10.12928/ijeme.v3i1.11648

INTRODUCTION

"Values convey what is important to us in our lives" (Bardi & Schwartz, 2003). What students consider important and value in their school mathematics learning reflects their beliefs relating to mathematics education (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002), and motivates how they might make use of appropriate or relevant cognitive tools (Hannula, 2012) to optimise their learning experience. These values also predict students' activity choices (Eccles & Wigfield, 1995). The same may be said of teachers when making professional decisions. Indeed, what parents and the wider culture value also affect how they support both cognitive and affective aspects of their children's mathematics learning, such as facilitating home revisions, encouraging problem-solving, and celebrating the children's engagement. In other words, there is a sociocultural dimension in the development and growth of what is being valued by an individual.

The different ways in which boys and girls perceive, learn and perform in school mathematics have led to the emergence of a key research area in mathematics education research, which relates to gender differences in the learning and teaching of the discipline. Many studies have been conducted and a number of perspectives have been put forward, including biological, social, and cultural were used, trying to explain these differences and similarities (Leder, Forgasz, & Solar, 1996). What about gender differences in the conative aspect of mathematics education then?

This article reports on a research study, which investigates, amongst other things, what boys and girls in Hong Kong schools value with regards to mathematics learning. The validated 'What I Find Important (in my mathematics learning)' [WIFI]

Received November 1, 2018; Revised March 2, 2019; Accepted March 12, 2019

questionnaire was administered to 1081 students in Hong Kong to assess what they value and consider important in their respective mathematics learning experiences. In particular, in this paper, the focus will be on how similarly or differently boys and girls value mathematics learning in the Hong Kong context and how this might develop over time as the students move through the grades, especially experiencing gender role expectation, transition from primary and secondary schools, and gender intensification.

The significance of the research reported in this article is that it provides us with new knowledge, i.e., how boys and girls value mathematics learning in the Hong Kong social context, to better understand how they engage with the subject at school. Given that values and valuing are motivational constructs that affect decisions and actions, this research has allowed us to examine how the boys and girls' valuing might explain mathematics learning behaviours and habits. Indeed, this approach of using values and valuing to account for boys and girls' decisions and actions is a novel one. Yet, both values and gender are culturally-laden constructs, which means that studies such as this which collect and analyse local data are needed to complement knowledge that has been constructed.

In this article we will also link these results with current academic knowledge about gender differences in mathematics and we will discuss plausible explanations. Before the data are presented, however, research literature relating to values and valuing in mathematics education will be reviewed, as well as literature referring to gender in mathematics education. The methodology for the WIFI Study will then be presented, which with its outline of how data is collected and analysed, will set the scene for the reporting of results and for the discussion.

Values and Valuing in Mathematics Education

Not only are students in East Asian contexts performing very well in international comparative tests such as TIMSS and PISA, but studies such as Byun and Park (2012) as well as Wei and Eisenhart (2011) have also reported that Asian students, especially East Asian students, in 'Western' education systems also perform better than their peers in school mathematics. These (East) Asian students attended the same schools as their peers. That is, they and their peers would have been taught by the same teachers, performed similar activities during mathematics lessons, attempted the same homework, and sat for the same assessment tasks. They would also have experienced the same classroom learning environment and conditions. Given these same opportunities to learn (at school), then, why do East Asian students perform better in school mathematics? Lee and Zhou's (2015) analysis of the mathematics performance of migrant children in the USA painted the same picture.

Several reports (e.g., Leung, 2006; Wei & Eisenhart, 2011) have made reference to culturally-based values in mathematics education. Askew, Brown, Rhodes, Wiliam, and Johnson (1997) might have stopped short of naming 'values' as the factor associated with the 'effective' teaching they observed, although they wrote about these teachers "believing in the importance of" (p. 4) particular pedagogical practices in their mathematics teaching repertoire. Later on, Askew, Hodgen, Hossain, and Bretscher (2010) claimed that: "one of the most striking things the review has shown is that high attainment may be much more closely linked to cultural values than to specific mathematics teaching practices" (p. 12). We have adopted Seah's (2018) definition of values/valuing in the context of mathematics learning and teaching:

Valuing refers to an individual's embrace of convictions, which are considered to be of importance and worth. It provides the individual with the will and grit to maintain any 'I want to' mindset in the learning and teaching of mathematics. In the process, this conative variable shapes the manner in which the individual's reasoning, emotions and actions relating to mathematics pedagogy develop and establish. (p. 31)

Research into the role of values and valuing in mathematics learning and teaching had begun with Alan Bishop's proposal of three pairs of complementary values relating to 'Western' mathematics' (Bishop, 1988). These are convictions in the discipline of mathematics that are taught in contemporary schooling. They are, namely, *rationalism* and *objectism*, *control* and *progress*, as well as *mystery* and *openness* (Bishop, 1988). Bishop (1996) later proposed that these mathematical values constitute but one of three categories of valuing that are often expressed in the mathematics classroom. One of these two other categories are the mathematics educational values, which are reflected in the pedagogical practices of school mathematics. The range of these values can be extensive, examples of which include *information and communication technology* [ICT], *practice*, *ability* and *effort*.

Bishop's (1996) third category of values in the mathematics classroom, general educational values, refers to the sorts of values which educational systems expect to inculcate in students through the school subjects. Examples would include honesty and creativity. They do not directly (if at all) affect mathematics performance, and thus they will not be discussed in this chapter.

The PISA 2012 data have shown that "the relationship between drive, motivation and mathematics-related self-beliefs on the one hand, and mathematics performance on the other, is particularly strong among the best-performing students" (OECD, 2014, p. 7). Given the nature of values as being a kind of drive and motivation, given the internalised nature of values, it should thus play a crucial role in students' mathematical performance. Hong Kong students' performance in PISA 2012 was ranked third best amongst the 65 countries/economies. Yet, do boys and girls in Hong Kong schools value mathematics and the learning of mathematics similarly? What might we learn from this top mathematics performing economy?

Mathematics Learning Values in Hong Kong Classrooms

Earlier Hong Kong classroom environment studies revealed that Hong Kong students preferred a better environment they actually perceive (Wong, 1995b). What they prefer is a light atmosphere, non-boring but with order kept in which the teacher is lively, with lessons well-prepared and ready to answer questions (Wong, 1993). This may be labelled as a teacher-led yet student centred classroom (Wong, 2004). Such preferences may be regarded as reflecting (at least partially) students' valuing in mathematics.

Several research studies have been conducted to identify what teachers and students value in the context of mathematics lessons. In a relatively recent study (Wong, Ding, & Zhang, 2016), 367 Primary Grade 5-6 students (11-12 years old) in Hong Kong responded to survey questions, which asked them what they found important in their mathematics learning. The 6 most valued attributes of mathematics learning were found to be similar across Hong Kong, mainland China and Taiwan, although the relative emphases amongst them are different. In Hong Kong, *achievement* was valued most, followed by *feedback, practice, relevance, communication,* and *ICT*. It is probable that the emphasis and importance given to *achievement* not just by Hong Kong students, but also by their peers in mainland China and Taiwan, might explain why they performed so well in the TIMSS and PISA rankings. It is as if the valuing of *achievement* provided students with the drive to 'push on' with their studies in order to achieve excellent scores, even if they might not be interested in the subject. However, it was found in a large-scale cross-territory study that both interest and confidence in mathematics among Hong Kong students drops sizably as they advance from junior Primary to Secondary levels (see Wong, Lam, Leung, Mok, & Wong, 1999; Wong, Ding, & Zhang, 2016).

Hong Kong teachers' values with regards to mathematics education have also been investigated in prior studies. Wong, Lam Wong, Leung, and Mok (2001) reported on part of a larger qualitative study with Hong Kong teachers, in which a Grade 7 teacher was the focus of the analysis. The multiple data sources suggested that this particular teacher valued *question-asking* and *student autonomy*.

Gender and Mathematics Education

Gender has been an issue of concern in mathematics education research for quite a long while, especially as mathematics has generally been perceived as a male domain (Fennema & Leder, 1990; Grevholm & Hanna, 1995). Findings from TIMSS and PISA – and especially the data they have collected and made available – have also stimulated much more recent research in this area (Hanna, 2000; Else-Quest, Hyde, & Linn, 2010).

Earlier findings have it that girls favour a more collaborative learning environment, while boys prefer a more competitive and problem solving learning environment (Owens & Straton, 1980). This was echoed in a subsequent article by Wong (1995a). There was a period of time when gender differences in mathematics performance were observed to be narrowing, though subtle differences persisted. However, gender differences can go beyond performances. For example, Jacobs et al.'s (2002) longitudinal study with predominantly European American students reported that "no significant gender differences in math values were found" (p. 524) across both primary and secondary schools, where "girls value math more than did boys by the end of high school" (p. 523) (see also Leder, 1992). Yet in another study, it was found that Hong Kong girls viewed mathematics as easier, more useful, and more interesting than boys did, although the effect size was small (Chiu, Wong, Lam, Wong, Leung, & Mok, 2005).

It is important to note, however, that gender difference in mathematics achievement has been increasingly reduced over the years. This is evident in Hanna's (2000) analysis of 1964 – 1995 Evaluation of Educational Achievement study data. Similarly, Else-Quest, Hyde, and Linn (2010) meta-analysed the data sets of the TIMSS 2003 and PISA 2003 studies and found evidence of similarities in mathematics achievement between boys and girls as well. Indeed, the "gender gap in mathematics performance has remained stable in most countries since 2003" (OECD, 2014, p. 8). In PISA 2012, "boys perform better than girls in mathematics in *only* 37 out of the 65 countries and economies that participated in PISA 2012, and girls outperform boys in five countries" (OECD, 2014, p. 4, emphasis added). Looked at it another way, although 15% of the boys performed at the highest levels of mathematics proficiency (13% OECD average), "there is evidence that in many countries and economies more boys than girls are among the lowest-performing students, and in some of these countries/economies more should be done to engage boys in mathematics" (OECD, 2014, p. 9). In the context of Hong Kong, the gender gap amongst her top performing students (about 10 percentage points), favoring boys, was the second highest amongst the 65 countries/economies. There were negligible gender gaps amongst Hong Kong's low performers, in line with what was observed also with most of the 65 countries / economies surveyed.

Although the gender differences in mathematics learning seem to be narrowing down (Else-Quest, Hyde, & Linn, 2010; Leder, 1992), the issue might have just become more subtle. Differences such as level of participation (Pustjens, Damme, & Munter, 2008; Tiedemann, 2002), learning style (Geist & King, 2008), teacher's attention (Leder, 1992), role taking in classroom activities (Horne, 2004), and favouring boys, are repeatedly found and such differences can start at an early age (Horne, 2004). Class ceiling effect is also there (Jakesch & Leder, 2009; Lee, 2002). Numerous studies point to the conclusion that girls are not necessarily less competent in mathematics but it all concerns social shaping, and more seriously girls' self-selection, i.e., they find it is not worth competing in a male domain (Fennema, Carpenter, Jacobs, Franke, & Levi, 1998; Leder, Forgasz, & Solar, 1996). Attention is moving from scores to affects, classroom environment/climate (Choi & Chang, 2011; Wong, 1995a, 1995b). Apparently, this concerns a core issue: value – how (not just 'how much') girls and boys value mathematics (Gaspard, Anna-Lena, Flunger, Schreier, Häfner, Trautwein, & Nagengast, 2015).

In an earlier study in Hong Kong (Wong, 1995a, 1995b), it was found that girls preferred a more harmonious mathematics classroom with the teachers being involved, whereas the boys perceived a more enjoyable learning environment. In fact, it was clear that girls placed greater value on social harmony and preferred competition less than boys, but at the same time girls were not less academically motivated than boys (Owens & Straton, 1980). What is more interesting is that the girls in that Hong Kong study were more dissatisfied with their classroom environment (Wong, 1995a, 1995b). More teacher attention is often directed to the boys and there is a greater need for teacher involvement among the girls (Zhang, Wong, & Lam, 2013).

A worrying trend is that the valuing of mathematics from both boys and girls decrease across the entire primary and secondary schooling period. For example, Jacobs, Lanza, Osgood, Eccles, and Wigfield (2002) analysed some 761 predominantly European American students' subjective task values, and observed this trend.

In addition, there is evidence that what boys and girls value in mathematics learning are different, even if they might be reporting the same performance. OECD (2014) reported amongst girls less valuing of perseverance and openness (to problem solving), leading to less self-belief and greater anxiety when compared to boys. Thus, the intricate link between the valuing of mathematics achievement and its effect on the formation of positive mathematics attitudes as a values component deserves further investigations (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). Such a comment is indeed consistent with the literature (Leder, 1992; Leder, Forgasz, & Solar, 1996) that urges us to pay particular attention to the affective constructs and values, including attitudes, beliefs, confidence, attribution of mathematical success and how the intersection of these notions demonstrate a complex interaction among themselves.

RESEARCH METHOD

Research Design

The data being analysed and reported here had been collected as part of Hong Kong's participation in the WIFI Study, an international study involving 21 teams for 20 countries around the world. Through the administration of a questionnaire that has been designed for the Study, student participants indicated the extent to which each of them values individual aspects of mathematics learning, such as small-group discussions, the use of textbooks, and problem solving. The questionnaire items were drawn from prior research studies on values and valuing in mathematics education (Dede, 2011; Tan & Lim, 2013). The WIFI Study's design reflects the theoretical perspective of interpretivism, and a methodology, which is survey research. Hong Kong provides an interesting context for the WIFI study, for it is one of the few East Asian economies with a Confucian Heritage Culture that have consistently been performing very well in both TIMSS and PISA assessments. An understanding of how students in Hong Kong value and perform in mathematics would contribute to the global interest in how East Asian economies lead the world in school mathematics performance.

Student participants responded to a validated questionnaire of the WIFI Study. The questionnaire items were initially subjected to a Principal Component Analysis and reliability tests using SPSSwin®. The questionnaire is generally considered to be suitable for assessing values (Reichers & Schneider, 1990), and it has been used in schools – including Hong Kong schools – as well as in mathematics pedagogy contexts (Govindaraj & Pa, 2014).

In an analysis of the WIFI questionnaire's data (Seah, Baba, & Zhang, 2017), the researchers identified nine value components, which are associated with what the Hong Kong students emphasised in their respective mathematics learning experiences. These are problem-solving, control, effort, ideas, recall, ICT, communication, broadening of mathematical vision, and learning approach.

In order to investigate how the primary and secondary students' gender might affect the extent to which each of the nine value components was embraced by students in Hong Kong, an Analysis of Variance (ANOVA) was conducted. A missing value analysis was also performed using multiple imputations. This was to ensure that our findings would not be statistically affected by missing values in any substantial number of questionnaire returns. No variable in this study had more than 5% missing values. The research question was the following: Are there gender differences between Hong Kong boys and girls in their valuing of mathematics?

Instrument

The research instrument was a questionnaire and it included 64 items. An online version of the questionnaire can be accessed at: https://melbourneuni.au1.qualtrics.com/jfe/form/SV_6YDuI41EnRFvozz. A Likert-type scoring format was used – students were asked to indicate the extent of importance of each statement presented from absolutely important (assigned a score of 1) to absolutely unimportant (assigned a score of 5). The questionnaire items were initially subjected to an exploratory factor analysis using SPSSwin®. A Principal Component Analysis (PCA) with Varimax rotation was used to examine the items. The significance level was set at .05, while a cut-off criterion for component loadings of at least .45 was used in interpreting the solution. The PCA indicates that the data satisfy the underlying assumptions of the factor analysis and that together nine components (each with eigenvalue greater than one explain 57.20% of the variance, with 12.32% attributed to the first component– Valuing the problem solving process with mathematical understanding (C1). The other 8 components are the following: Valuing control through linkage with mathematics outside the classroom (C2); Valuing effort through mathematics practice and assessment (C3); Valuing ideas through mathematical discourse (C4); Recalling known facts and routine manipulation (C5);

Using ICT in mathematics (C6); Feedback, dialogue and interaction (C7); Broadening of mathematical vision (C8) and Learning approach (C9) (Appendix 1). Further, if the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy is greater than 0.6 and the Bartlett's test of sphericity (BTS) is significant then factorability of the correlation matrix is assumed. A matrix that is factorable should include several sizable correlations. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy in this study is greater than 0.85 and the Bartlett's test of sphericity (BTS) is significant at 0.001 level, so factorability of the correlation matrix has been assumed.

Reliability analysis yield satisfactory Cronbach's alpha values for each factor: Factor 1, 0.97; Factor 2, 0.95; Factor 3, 0.93; Factor 4, .90 and Factor 5, 88, Factor 6. .85, Factor 7, .80, Factor 8, 77 and Factor 9, .70. These values indicate a moderate to strong degree of internal consistency in each factor.

Participants

The participants were 1081 upper primary school (Grade 5 and 6) and secondary school (Grade 8 and 9) students (Table 1), from various metropolitan Hong Kong schools in order to establish representative samples across different school locations and different school characteristics at the level of selected student populations defined in terms of grade level (with regard to the equivalent age group for cross-regional comparisons).

Table 1. Sample by Grade Level and Gender

Grade		Gender		Total
		Male	**Female**	
Grade Level	Grade 5 (11 years old)	97	145	242
	Grade 6 (12 years old)	46	79	125
	Grade 8 (14 years old)	147	143	290
	Grade 9 (15 years old)	196	228	424
	Total	**486**	**595**	**1081**

Data Analysis

An initial data screening was carried out to test for univariate normality, multivariate outliers (using Mahalanobis' distance criterion), homogeneity of variance-covariance matrices (using Box's M tests), and multicollinearity and singularity. The ANOVA findings by gender will be discussed next.

RESULTS AND DISCUSSION

One thousand and thirty-seven students (473 boys and 564 girls) declared their gender and completed all items (Table 2)

Table 2. Sample by Gender

		Value Label	N
Gender	1	Boys	473
	2	Girls	564

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 the three components (C1, C3, and C4) for which the F-tests are significant. Therefore homogeneity of variance has been assumed.

Pillai's Trace criterion was used to test whether there are significant group differences on a linear combination of the dependent variables. Since the multivariate effect for gender is significant ($p < 0.001$, $\eta^2 = .114$), we 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 0.006 (0.05/9). Using this alpha level, we have significant univariate main effects for the following variables:

1. *Component 1: Valuing the problem solving process with mathematical understanding* [[$F(1, 1037) = 11.788$, $p < 0.001$, $\eta^2 = 0.012$]
2. *Component 3: Valuing effort through mathematics practice and assessment* [$F(1, 1037) = 21.928$, $p < 0.001$, $\eta^2 = 0.022$]
3. *Component 4: Valuing ideas through mathematical discourse* [$F(1, 1037) = 12.396$, $p < 0.001$, $\eta^2 = 0.012$]

The estimated marginal means for the three components (C1, C3, and C4) by gender indicate that:

1. Girls had a higher mean in *Component 1* (i.e., boys valued higher in C1)
2. Girls had a higher mean in *Component 3* (i.e., boys valued higher in C3)
3. Boys had a higher mean in *Component 4* (i.e., girls valued higher in C4)

Table 3 shows the values components by gender towards the three components as constituted in the three core values, namely, *meaningfulness (V1), autonomy (V2),* and *positive attitude (V3)*. These three facets of values are elaborated as follows (see Seah & Wong, 2012).With meaningfulness, students prefer to have a 'nice' atmosphere in which the classroom learning can create a feeling of 'enjoyment' as well as the 'cognitive meaningfulness' in terms of something learned through active classroom engagement

Table 3. Description of values components by gender

Core values	Valued higher by boys	Valued higher by girls
V1 Meaningfulness	*Valuing the problem solving process with mathematical understanding*	No *statistically* significant differences
V1 Meaningfulness	*Valuing the problem solving process with mathematical understanding*	No *statistically* significant differences
V2 Autonomy	No *statistically* significant differences	*Valuing ideas through mathematical discourse*
V3 Positive attitudes	*Valuing effort through mathematics practice and assessment*	No *statistically* significant differences

With *autonomy*, the effects of the use of mathematics in society should be viewed as a 'complex and broad set of social activities' through which the individual learners can see themselves as "free, autonomous, productive" agents. With *positive attitudes*, students engage positively in classroom activity. The learners want to know what their efforts in learning mathematics would give them in return. Through teacher-led monitoring and teacher support, students can have a better chance of getting the incentives or rewards as required for their learning.

The results suggest that there were no statistically significant gender differences for the 11- and 12-year olds when we removed the secondary students' data. This means that all the gender differences we identified in the ANOVA in which the primary and secondary students were combined, are due to 14 -15 year-old gender differences. This result is in concord with some of the results documented in gender differences in mathematics literature (see Hyde, Fennema & Lamom, 1990; Lachance & Mazzocco, 2006) though based on what we know it is not exactly clear whether there exists a difference between the 14- and 15-year olds, or whether there exists a difference between the primary and secondary school students. Two components, namely, *valuing the problem solving process with mathematical understanding*, and *valuing effort through mathematics practice and assessment*, were valued more by boys than girls; whereas girls valued only one values component more than their male peers, that is, *Valuing ideas through mathematical discourse* (Table 3).

In terms of the core categories, boys were found to be valuing *meaningfulness* and *positive attitudes* more than girls, whilst girls valued *autonomy* more than their male peers. Eccles and Jacobs (1986) argued that, the value of mathematics as embraced by students constitutes at least part of the social forces that influence plans to continue taking mathematics courses in their future studies. One of the observations they have drawn from prior literature included that "males are more likely than females to engage in a variety of optional activities related to mathematics, from technical hobbies to careers in which math skills play an important role" (p. 367). It is thus interesting to interpret boys' preference for these optional mathematical activities in terms of their valuing of *meaningfulness* and *positive attitudes*. That is, the desire or preference to seek the *extra* mathematical activities, such as doing problem solving beyond the demand from the teachers in terms of the efforts as required for the work and the difficulty of the problems to be solved. Striving for greater mathematical achievement through more practice reflects a search for meaningfulness, and this process is facilitated by a certain level of *positive attitudes* that boys create or identify for themselves.

Furthermore, we also noticed that girls valued *ideas through mathematical discourse* more than boys. This is another component, which constitutes the autonomy of learning. This means that female students valued more than their male peers their own voices as learners to be heard in the classrooms. This result deserves our attention as we strive to enhance female students' self-concept through promoting their participation in problem solving, including non-routine problem solving (McLeod, 1992). For female students, the desire of having their voices heard in the mathematics classroom could turn itself up into a struggle between subjection and autonomy (Seah & Wong, 2012). If we adopt gender equity (see Fennema, 1990) as an important research agenda in mathematics education, we should treat the female preference and valuing of autonomy through the learning of the discourse of the mathematics lessons seriously. This finding may add depth to understanding those of Kane and Mertz (2012), who have showed that the gender gap in mathematics performance is "largely artefacts of a complex variety of sociocultural factors rather than intrinsic differences" (p. 11).

Table 3 highlights another side of the story, that is, that boys valued *positive attitudes* more than girls, where the boys specifically valued the *effort* they expended for their engagement in the assigned classroom tasks through mathematics practice and assessment. These tasks include "doing a lot of mathematics work", "practicing with lots of questions", doing "mathematics homework", "completing mathematics work", and preparing for "mathematics tests or examinations". Fennema (1989) argued that success in doing mathematical tasks provokes a sense of belief in being more capable of completing those tasks. This result urges us to consider how teachers can provide opportunities for students to develop depth of understanding in practicing mathematical tasks so as to enhance a positive attitude in mathematics learning.

In looking more deeply into the issue of gender, there appears to be a narrowing trend of gender difference in terms of mathematical achievement in Hong Kong (Law, Wong, & Lee, 2012) and in other places as well, such as UK, Japan, and Sweden (Boaler & Sengupta-Irving, 2006). And yet, the notion of the 'glass ceiling' (Lee, 2002) used as a conceptual tool for alerting us about the possible existence of gender inequality deserves our attention. Based on the understanding of such a notion, we should be aware that the ways in which boys and girls value the importance of learning mathematics in their younger age could have an effect of imposing barriers to achievement. The Hong Kong data does not reveal significant difference in valuing between the boys and girls at the younger ages, whereas it is in the older ages where we did see a difference in valuing between male and female students. Nonetheless, the values components as exhibited by both genders would affect the ways the school children interpret their learning experiences in the discipline of mathematics. Such differences, though subtle, would have serious consequences on their learning of mathematics in later stages if it is not attended to.

CONCLUSION

In conclusion, the present study has demonstrated how questionnaire data on students' valuing can be further interrogated and analysed quantitatively to explore the influence of gender on Hong Kong students' mathematics learning values, while acknowledging that both gender and values are culturally-mediated constructs. It is hoped that the instrument used in the study will facilitate a better understanding of how values might affect students' mathematics learning across different regions. Though we can acquire deep understanding of students' values via qualitative methods (see Bishop, Clarke, Corrigan, & Gunstone, 2005; Chin, Leu, & Lin, 2001; Wong, Lam, Wong, Leung, & Mok, 2001; Seah & Ho, 2009) the WIFI questionnaire enables us to conduct studies with large samples, and analyse and interpret the collected quantitative data statistically so that meaningful cross-cultural comparisons are possible. Being able to use the valuing discourses to explain observed differences between groups of students, opens up other fronts of possibilities of addressing these differences, in terms of values modification, negotiation, and alignment. From the perspective of pedagogical implications, the present study has the potential to enable teachers to discern how students of both genders interpret the values of mathematics learning. Indeed, teachers, administrators and curriculum planners could use the findings to enrich their understanding of what their students' value in mathematics learning and to use this knowledge to better plan and deliver mathematics teaching experiences in school.

Students learn more effectively in environments closer to their preferences (Fraser, 1994; Wong, Ding, & Zhang, 2016). These preferences vary with gender and as shown by the present study, girls and boys do have differences at a deeper level: how they value mathematics and mathematics education. Though these gender differences may play out differently in different cultures, it is important for teachers to be aware of such differences (and similarities too), and to plan their lessons in ways where there is generally co-valuing of mathematics and its pedagogy between these teachers and their students. It could be argued that the difference in valuing between male and female students is likely to be unnoticed by the teachers themselves (Billington, 1993), teachers should attempt to gear their teaching to suit learners of both genders in the first instance

REFERENCES

Askew, M., Brown, M., Rhodes, V., Wiliam, D., & Johnson, D. (1997). The contribution of professional development to effectiveness in the teaching of numeracy. *Teacher Development*, *1*(3), 335-356.

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

Bardi, A., & Schwartz, S.H. (2003). Values and behavior: Strength and structure of relations. *Personality and Social Psychology Bulletin, 29*(10), 1207-1220.

Billington, T. (1993). Sex differences in student estimations of female and male student-teacher interaction. *Research in Education, 50*(1), 17-26.

Bishop, A., Clarke, B., Corrigan, D., & Gunstone, D. (2005). Teachers' preferences and practices regarding values in teaching mathematics and science. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce & A. Roche (Eds.), *Building connections: Research, theory and practice* (Vol. 1, pp. 153-160). Sydney, Australia: Mathematics Education Research Group of Australasia.

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

Bishop, A.J. (1996). 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.

Boaler, J., &Sengupta-Irving, T. (2006). Nature, neglect and nuance: Changing accounts of sex, gender and mathematics, (pp. 207–220). In C. Skelton, B. Francis, & L. Smulyan(Eds.), *The Sage handbook of gender and education*, London/Thousand Oaks/New Delhi: Sage Publications

Byun, S.-y., & Park, H. (2012). The Academic Success of East Asian American Youth. *Sociology of Education, 85*(1), 40-60.

Chin, C., Leu, Y.-C., & Lin, F.-L. (2001). Pedagogical values, mathematics teaching, and teacher education: Case studies of two experienced teachers. In F.-L. Lin & T. J. Cooney (Eds.), *Making sense of mathematics teacher education* (pp. 247-269). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Chiu, M.M., Wong, N.Y., Lam, C.C., Wong, K.M.P., Leung, F.K.S., & Mok, I.A.C. (2005). Architectures of mathematics beliefs: Individual and school-level differences among Hong Kong Primary 6 students. *Educational Research Journal, 20*(1), 27-55.

Choi, N., & Chang, M. (2011). Interplay among school climate, gender, attitude toward mathematics, and mathematics performance of middle school students. *Middle Grades Research Journal*, *6*(1), 15-29.

Dede, Y. (2011). Mathematics education values questionnaire for Turkish preservice mathematics teachers: Design, validation, and results. *International Journal of Science and Mathematics Education, 9*(3), 603-626.

Eccles, J.S., & Jacobs, J.E. (1986). Social forces shape math attitudes and performance. *Signs: Journal of women in culture and society*, *11*(2), 367-380.

Eccles, J.S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin*, *21*(3), 215-225.

Else-Quest, N.M., Hyde, J.S., & Linn, M.C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*(1), 103-127.

Fennema, E. (1990). Justice, equity, and mathematics education, (pp. 1–9). In E. Fennema & G. C. Leder (Eds.), *Mathematics and gender*, New York & London: Teachers College Press.

Fennema, E., & Leder, G.C. (Eds.) (1990). *Mathematics and gender*. New York: Teachers College Press.

Fennema, E., Carpenter, T.P., Jacobs, V.R., Franke, M.L., & Levi, L.W. (1998). New perspectives on gender differences in mathematics: A reprise. *Educational researcher*, *27*(5), 19-21.

Fraser, B. J. (1994). Research on classroom and school climate. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 493–541). New York, U.S.A.: Macmillan.

Gaspard, H., Dicke, A.L., Flunger, B., Schreier, B., Häfner, I., Trautwein, U., & Nagengast, B. (2015). More value through greater differentiation: Gender differences in value beliefs about math. *Journal of educational psychology*, *107*(3), 663.

Geist, E.A., & King, M. (2008). Different, not better: Gender differences in mathematics learning and achievement. *Journal of Instructional Psychology*, *35*(1), 43-53.

Govindaraj, J., & Pa, N.A.N. (2014). The development of an instrument to assess primary school mathematics teachers' values in teaching fractions. *World Applied Sciences Journal, 30*, 81-84. doi:10.5829/idosi.wasj.2014.30.icmrp.12

Grevholm, B. & Hanna, G. (Eds.) (1995). *Gender and mathematics education*. Lund: Lund University Press.

Hanna, G. (2000). Declining gender differences from FIMS to TIMSS. *Zentralblatt für Didaktik der Mathematik*, *32*(1), 11-17.

Hannula, M.S. (2012). Exploring new dimensions of mathematics-related affect: embodied and social theories. *Research in Mathematics Education*, *14*(2), 137-161.

Horne, M. (2004). Early gender differences. In M. J. Johnsen Høines& A. B. Fuglestad (Eds.), Proceedings of the 28th conference of the International Group for the Psychology of Mathematics Education (Vol. 3, pp. 65-72). Bergen, Norway: Bergen University College.

Hyde, J.S., Fennema, E., & Lamon, S.J. (1990). Gender difference in mathematics performance: A meta-analysis. *Psychological Bulletin, 107*(2), 139-155.

Jacobs, J.E., Lanza, S., Osgood, W., Eccles, J.S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development, 73*(2), 509-527.

Jakesch, M., & Leder, H. (2009). Finding meaning in art: Preferred levels of ambiguity in art appreciation. *The Quarterly Journal of Experimental Psychology*, *62*(11), 2105-2112.

Kane, J.M., & Mertz, J.E. (2012). Debunking myths about gender and mathematics performance. *Notices of the AMS, 59*(1), 10-21.

Lachance, J., & Mazzocco, M.M.M. (2006). A longitudinal analysis of sex differences in math and spatial skills in primary school age children. *Learning and Individual Differences, 16*(3), 195–216.

Law, H.Y., Wong, N.Y., & Lee, N.Y. (2012). A study into espoused values in Hong Kong mathematics classrooms. *ZDM - The International Journal on Mathematics Education, 44*(1), 45-57.

Leder, G.C., Forgasz, H.J., & Solar, C. (1996). Research and intervention programs in mathematics education: A gendered issue. In A. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International handbook of mathematics education* (Part 2, pp. 945-985). Dordrecht, Netherlands: Kluwer.

Leder, G.C. (1992). Mathematics and gender: Changing perspectives. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 597-622). New York, NY, England: Macmillan Publishing Co, Inc.

Lee, D. (2002). Gendered workplace bullying in the restructured UK civil service. *Personnel review, 31*(2), 205-227.

Lee, J., & Zhou, M. (2015). *The Asian American achievement paradox*. NY: Russell Sage Foundation.

Lee, S.M. (2002). Do Asian American faculty face a glass ceiling in higher education? *American Educational Research Journal, 39*(3), 695-724.

Leung, F.K.S. (2006). Mathematics education in East Asia and the West: Does culture matter? In F. 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). NY: Springer.

McLeod, D. B. (1992). Research on affect in mathematics: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575-596). New York: MacMillan.

OECD. (2014). *PISA 2012 results: Ready to learn: Students' engagement, drive and self-beliefs*. Retrieved from Paris, France:

Owens, L., & Straton, R.G. (1980). The development of a co-operative, competitive, and individualised learning preference scale for students. *British Journal of Educational Psychology*, *50*(2), 147-161.

Pustjens, H., Damme, J.V., & Munter, A.D. (2008). Mathematics participation and mathematics achievement across secondary school: The role of gender. *Sex Roles*, *59*(7-8), 568-585.

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., & Ho, S.Y. (2009). Values operating in effective mathematics lessons in Australia and Singapore: Reflections of pre-service teachers. In M. Tzekaki, M. Kaldrimidou & H. Sakonidis (Eds.), *Proceedings of the 33rd conference of the International Group for the Psychology of Mathematics Education* (Vol. 5, pp. 57-64). Thessaloniki, Greece: International Group for the Psychology of Mathematics Education.

Seah, W.T., & Wong, N.Y. (2012). What students value in effective mathematics learning: A 'Third Wave Project' research study. *ZDM Mathematics Education, 44*(1), 33-43.

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). Cham, Switzerland: Springer International Publishing.

Seah, W.T. (2018). Improving mathematics pedagogy through student/teacher valuing: Lessons from five continents. In G. Kaiser, H. Forgasz, M. Graven, A. Kuzniak, E. Simmt, & B. Xu (Eds.), *Invited Lectures from the 13th International Congress on Mathematical Education* (pp. 561-580). Cham, Switzerland: Springer International Publishing.

Tan, S.F., & Lim, C.S. (2013). Effective mathematics lesson from the eyes of primary pupils. In M. Inprasitha (Ed.), *Proceedings of the 6th East Asia Regional Conference on Mathematics Education* (Vol. 2, pp. 184-193). Khon Kaen, Thailand: Centre for Research in Mathematics Education.

Tiedemann, J. (2002). Teachers' Gender Stereotypes as Determinants of Teacher Perceptions in Elementary School Mathematics. *Educational Studies in Mathematics, 50*(1), 49-62.

Wei, M.-H., & Eisenhart, C. (2011). Why do Taiwanese children excel at math? *The Phi Delta Kappan, 93*(1), 74-76.

Wong, N.Y. (2004). The CHC learner's phenomenon: Its implications on mathematics education. In 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., Ding, R., & Zhang, Q.P. (2016). From classroom environment to conception of mathematics. In R. B. King, & A. B. I. Bernardo (eds.), *The psychology of Asian learners* (pp. 541-557). Singapore: Springer.

Wong, N.Y., Lam, C.C., Leung, F.K.S., Mok, I.A.C., & Wong, K.M.P. (1999). Holistic reform of the mathematics curriculum – the Hong Kong experience. *Journal of the Korea Society of Mathematical Education Series D: Research in Mathematical Education*, *3*(2), 69-88.

Wong, N.Y. (1993). The psychosocial environment in the Hong Kong mathematics classroom. *The Journal of Mathematical Behavior, 12*(3), 303-309.

Wong, N.Y. (1995a). *The relationship between Hong Kong students' perception of their mathematics classroom environment and their approaches to learning: A longitudinal study*. Unpublished Ph.D. thesis. Hong Kong: The University of Hong Kong.

Wong, N.Y. (1995b). Discrepancies between preferred and actual mathematics classroom environment as perceived by students and teachers in Hong Kong. *Psychologia, 38*(2), 124-131.

Wong, N.Y., Lam C.C., Wong, K.M.P., Leung, F.K.S., & Mok, I.A.C. (2001). Students; views of mathematics learning: A cross-sectional survey in Hong Kong. *Education Journal*, *29*(2), 37-59.

Zhang, Q.P., Wong, N.Y., & Lam, C.C. (2013). Teacher's gender-related beliefs about mathematics. *Journal of the Korean Society of Mathematical Education Series D: Research in Mathematical Education, 17*(3), 153–167.

Appendix 1.

Principal Component Analysis: Rotated component matrix

	Component								
	1	2	3	4	5	6	7	8	9
Valuing the problem solving process with mathematical understanding									
Q56 Knowing the steps of the solution	.748								
Q54 Understanding concepts processes	.708								
Q55 Shortcuts to solving a problem	.703								
Q51 Learning through mistakes	.655								
Q58 Knowing which formula to use	.604								
Q63 Understanding why my solution is incorrect or correct	.593								
Q50 Getting the right answer	.588								
Q59 Knowing the theoretical aspects of mathematics	.564								
Q49 Examples to help me understand	.546								
Q2 Problem solving	.530								
Q47 Using diagrams to understand Maths	.491								
Q53 Teacher use of keywords	.490								
Valuing control through linkage with mathematics outside the classroom									
Q17 Stories about Mathematics		.760							
Q61 Stories about Mathematicians		.754							
Q18 Stories about recent developments in Mathematics		.696							
Q34 Outdoor Mathematics activities		.666							
Q25 Mathematics games		.559							
Q52 Hands-on activities		.555							
Q20 Mathematics puzzles		.472							
Q40 Explaining where the rules, formulae came from									
Valuing effort through mathematics practice and assessment									
Q37 Doing a lot of mathematics work			.849						
Q36 Practicing with lots of questions			.822						
Q57 Mathematics homework			.732						
Q62 Completing mathematics work			.690						
Q43 Mathematics tests examinations			.519						
Valuing ideas through mathematical discourse									

Q30 Alternative solutions	.687					
Q21 Students posing Maths problems	.601					
Q31 Verifying theorems hypotheses	.593					
Q29 Making up my own Maths questions	.585					
Q19 Explaining my solutions to the class	.487					
Q16 Looking for different possible answers	.476					
Recalling known facts and routine manipulation						
Q28 Knowing the times tables		.629				
Q14 Memorizing facts		.570				
Q38 Given a formula to use		.548				
Q13 Practicing how to use Maths formulae		.517				
Q32 Using mathematical words		.513				
Using ICT in mathematics						
Q22 Using the calculator to check the answer			.802			
Q23 Learning Maths with the computer			.760			
Q4 Using the calculator to calculate			.724			
Q24 Learning Maths with the internet			.692			
Feedback, dialogue and interaction						
Q45 Feedback from my friends				.666		
Q44 Feedback from my teacher				.646		
Q46 Me asking questions				.485		
Q48 Using concrete materials to understand Mathematics				.452		
Broadening of mathematical vision						
Q10 Relating Mathematics to other subjects in school					.636	
Q12 Connecting Maths to real life					.553	
Q11 Appreciating the beauty of Mathematics					.549	
Q8 Learning the proofs					.485	
Learning approach						
Q5 Explaining by the teacher						.550
Q7 Whole class discussions						.493
Q6 Working step by step						.485
Q3 Small group discussions						.470