The Mathematics Educator
2013, Vol. 15, No. 1, 66-80

Senior Secondary Students' Perceptions of Mathematics Classroom Learning Environments in China and Their Attitudes Towards Mathematics

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Abstract: This paper investigated how senior secondary school students in China perceived their mathematics classroom environments and the relationship between their perceptions and attitudes towards mathematics. The widely used "What Is Happening In This Classroom?" questionnaire was adapted and data were collected from 994 Grade 10, 966 Grade 11, and 657 Grade 12 students from 75 classrooms in six provinces in China. These senior secondary students generally did not perceive their mathematics classroom environments very favorably and did not hold positive attitudes towards mathematics. Positive correlations between mathematics classroom learning environments and attitudes towards mathematics were identified. Gender differences and grade differences of students' perceptions of their classroom learning environments were found. Findings of this study may provide those who are interested in Chinese mathematics education a window to understand Chinese mathematics teaching practice from the students' perspective. This study may further stimulate comparative study of mathematics learning environments in China and other countries, and this can contribute to the understanding of how mathematics learning environment is influenced by social and cultural contexts and its associations with students' attitudes towards mathematics.

Keywords: Mathematics classroom learning environment; Attitudes towards mathematics; Senior secondary school students; China

Background

Recently, there has been an increasing interest in international research to investigate Chinese mathematics education because Chinese students have consistently outperformed their western counterparts in international comparative studies in mathematics achievement (e.g., Fan et al., 2004; Li & Huang, 2012). Since classroom teaching is a crucial influence on students' mathematics learning outcomes, there are a growing number of studies focusing on how Chinese mathematics teachers teach mathematics. However, paradoxically, these studies find that mathematics is not taught and learned in a favorable environment in China (Biggs, 1998; Watkins & Biggs, 1996, 2001). For example, class size in China is close to or larger than 50, much larger than class size in western countries (Biggs, 1998). Due to the restriction of large class size, it is quite common for Chinese mathematics teachers to employ whole class instruction (Paine, 1990) and teachers take the major role to organize the lesson, control the transaction of classroom activities, and dominate the interaction (Biggs, 1998; Mok & Lopez-Real, 2006). In addition, Chinese mathematics teaching has been described as being dominated by mastery of knowledge and practice of problem solving skills, which are important for students' success in external examinations (Shao et al., 2012; Zheng, 2006).

This kind of teacher-dominated and knowledge-centered mathematics teaching is rather traditional, especially from the western perspective (Biggs, 1998; Zheng, 2006). In the meantime, Chinese students' outstanding performance is not accompanied by positive attitudes towards mathematics and mathematics learning (Leung, 2006). In China, mathematics teaching prior to 2000 is considered "traditional" while after 2000 it is called "reformed." Changes include reforming the mathematics curriculum (e.g., its objectives and content), mathematics teaching, and assessment practices in order to enrich the students' mathematics learning experiences and develop positive affective outcomes (Liu & Li, 2010). For example, the content in the latest national Senior Secondary Mathematics Curriculum Standard in China, released in 2003, consists of compulsory and elective parts. The compulsory parts are the basis of the senior secondary school mathematics curriculum and are completed in Grade 10 and the first half of the first semester of Grade 11. There are four elective courses to cater for different student interests and orientations. They start to take the elective courses in Grade 11. This design of the senior secondary school mathematics curriculum enables students to choose the most suitable content and topics for their future development rather than learning the same required content for every student in the whole country under the traditional curriculum.

In addition to the acquisition of basic mathematical knowledge and skills, students' positive mathematical emotion, attitudes, and values are now stressed as a main goal of mathematics teaching. The latest document states that mathematics teaching should aim to develop in students the ability to raise, analyze, and solve problems from a mathematical perspective and the ability to mathematically express and communicate their ideas. Mathematics teaching should also encourage students to apply mathematics in real world contexts and foster students' interest and confidence in learning mathematics (Ministry of Education, 2003).

This recent curriculum has now been adopted by almost all senior secondary schools across the country. Arguably, this type of mathematics curriculum could reform the traditional Chinese mathematics teaching culture and practices. If the reforms are implemented effectively, the reformed teaching culture will give students different mathematics experiences. These experiences should in turn help students develop different perceptions of their mathematics classroom learning environment, since culture determines "how we experience and interpret the world" (Clarke, 2013, p. 31). The reformed classroom learning environment will then change students' attitudes towards mathematics since mathematics classroom learning environment is a major determinant of not only students' cognitive outcomes but also their affective outcomes (Fraser, 1998, 2007, 2012). Thus, information collected from students is meaningful and necessary for understanding the Chinese mathematics teaching culture and the effectiveness of the implementation of the reformed mathematics curriculum.

Currently, most of the characteristics of Chinese mathematics classrooms are described by researchers from outside the Chinese classroom, and there are few studies that investigate students' opinions about their experience in mathematics classrooms. Most of these studies focus on mathematics teaching at the primary and junior secondary school levels, with a gap about what happens at the senior secondary school level. This study aimed to address these issues by answering the following research questions:

1. What do senior secondary school students perceive about their mathematics classroom learning environment and do these perceptions differ by gender and grade levels?
2. What are their attitudes towards mathematics under the reformed curriculum background?
3. What are the associations between students' perceptions of mathematics learning environment and their attitudes toward mathematics?

Literature Review

The development of students' positive attitudes towards mathematics is a key intended outcome of mathematics curriculum at each grade level in most countries (Leung, 2006). In the literature, students' attitudes towards mathematics have been described as an important factor which will hinder or facilitate their mathematical learning and engagement (Hemmings, Grootenboer, & Kay, 2011; Ma & Kishor, 1997). McLeod (1992) argued that attitude towards mathematics is an important variable for predicting students' performance in other affective domains as well as mathematics achievement. Studies in educational psychology and mathematics education have identified strong relationships between attitudes and cognition, motivation, and mathematics achievement (e.g., Hannula, 2002; Muis, 2004).

The main factors that play a vital role in influencing students' attitudes towards mathematics are associated with the students themselves; the school, teachers, and teaching; and home environment and society (Mohamed & Waheed, 2011). Since teaching is a main factor, it is reasonable to conjecture that mathematics classroom learning environment is an also important for the development and change of students' attitudes toward mathematics. Indeed, Moos (1979) argued several decades ago that "the social ecological setting in which students function can affect their attitudes and moods, their behavior and performance and their self-concept and general sense of well-being" (p. 3). Since then, there has been an increasing interest to develop and employ instruments to assess students' perceptions of their classroom learning environments (e.g., Fraser, 1998, 2007, 2012). The strongest tradition in classroom learning environment research relates to the investigation of associations between students' perceptions of the psychosocial characteristics of their classrooms and their cognitive and affective outcomes (Fraser, 2012). This tradition has been extended to mathematics education in the recent years. Researchers from various culture backgrounds have investigated these associations in mathematics learning (Majeed, Fraser, & Aldridge, 2002) and academic efficacy (Dorman, 2001). For example, in Australia, Forgasz (1995) found that students who scored high in participation and investigation in mathematics class tend to have high scores on confidence in mathematics and usefulness of mathematics, and Webster and Fisher (2003) found a significant and positive effect of instructional practices on secondary school students' attribution of success. A study in the U.S. (Ogbuehi & Fraser, 2007) identified a positive relationship between learning environment and attitudes towards mathematics at the middle school level. In Singapore, Goh and Fraser (1998) found that primary school students who perceived to have more student cohesiveness in their lessons tend to have more positive attitudes towards mathematics. At Grade 10 level in Singapore, students tend to have more positive attitudes if they perceived more support from their teachers and were treat equally by their teachers in mathematics class (Chionh & Fraser, 2009). The review found very few studies about mathematics classroom learning environment in China, especially at senior secondary schools under the present curriculum reform. This study was an attempt to bridge these gaps.

Methods

Student sample

The 2617 students involved in this study were conveniently chosen from coeducational schools, although factors such as their academic backgrounds, school reputation, and teachers' teaching experience (ranging from 2 to 29 years) were considered. They were from 75 classes selected from 16 urban schools situated in six China provinces, namely Xinjiang, Yunnan, Guizhou, Chongqing, Jiangsu, and Hunan. Table 1 summarizes the background information of the sample.

Table 1
Background characteristics of the students

Grade	Gender			Total
	Female	Male	NA	
10	535	440	19	994
11	492	445	29	966
12	360	242	55	657
Total	1387	1127	103	2617

Development and validation of instruments

Classroom learning environment questionnaire. A short modified version of the “What Is Happening In this Class?” (WIHIC) questionnaire was developed. It is the most widely used classroom environment research instrument (Fraser, 2007, 2012) and has been cross-validated in various cultural contexts, such as Australia, United Kingdom, and Canada (Dorman, 2003) and Taiwan (Huang, Aldridge, & Fraser, 1998).

In this study, the following six scales from the original questionnaire were used: *Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation*, and *Cooperation.* For each scale, six items were chosen. The selected items were first translated into Chinese by the author based on the Mandarin version developed by Huang et al. (1998). To enhance the suitability of WIHIC in the Chinese context, a university mathematics education researcher and a highly experienced secondary school mathematics teacher in China were invited to make modifications to the translated draft of WIHIC. As items in the *Investigation* scale were originally designed for science education, six items in this scale had to be re-designed, and this was completed together by the author, the mathematics education researcher, and the secondary school mathematics teacher. The modified version of WIHIC was further checked by five highly experienced secondary school mathematics teachers and two experienced mathematics education researchers in China. Modifications were further made according to their suggestions. The modified version of WIHIC had a 5-point Likert-type response options: (1) Never, (2) Seldom, (3) Sometimes, (4) Often, (5) Always. Table 2 provides detailed descriptions of what each scale measures and a sample item.

Table 2
Description, sample item, and Cronbach's alphas for the modified WIHIC scales

Scale	Description	Sample item	Cronbach's α
Student Cohesiveness	Extent to which students know, and be friendly to each other	I am friendly to members in my mathematics class.	0.793
Teacher Support	Extent to which the teacher helps, befriends, trusts and is interested in students	My mathematics teacher goes out of his her way to help me in class.	0.797
Involvement	Extent to which students have attentive interest, participate in discussions, and explain their solutions	I am asked to explain how I solve a problem.	0.796
Investigation	Extent to which skills and processes of inquiry and their use in class	I find out answers to questions by carrying out some inquiries in class.	0.814
Task Orientation	Extent to which it is important to complete activities planned and to stay on the subject matter	I know what I am trying to accomplish in the mathematics class.	0.746
Cooperation	Extent to which students cooperate rather than compete with one another on learning tasks	I cooperate with other students on mathematics class activities.	0.847

Principal components analysis (with varimax rotation) was used to confirm the a priori conceptual structure of WIHIC. This led to the removal of several items with factor loadings smaller than 0.40. The final modified WIHIC consisted of 28 items. Cronbach's alphas were high, ranging from 0.746 to 0.847. These results confirm the sound reliability of the modified version of the WIHIC.

Mathematics attitudes questionnaire. Two scales, *Motivation in Mathematics* and *Confidence in Learning Mathematics*, were developed by selecting and modifying items chosen from the *Mathematics Attitudes Scale* developed by Fennema and Sherman (1976). The *Motivation* scale included lack of involvement in mathematics, active enjoyment, and seeking of challenge. A sample item was: When a question is left unanswered in math class, I continue to think about it afterwards. The *Confidence* scale measured confidence in one's ability to learn and to perform well on mathematical tasks, and a sample item was: I am sure that I can learn mathematics. Each subscale consisted of 6 items, and a 5-point Likert scale was used (5 = strongly agree to 1 = strongly disagree).

Findings

General perception of classroom environment and attitudes

The descriptive statistics are given in Table 3. The item means of the WIHIC scales ranged from 2.80 to 3.93, all lower than 4, and five means were close to 3, which were lower than results found in other contexts (e.g., Afari, Aldridge, & Fraser, 2012; Opolot-Okurut, 2010). This suggests that the students did not perceive their senior secondary school mathematics classroom environment in favorable terms. Nevertheless, the highest mean was obtained for *Student Cohesiveness* (3.93), and this suggests that the students were friendly to one another in class. The students stated that they were less than often but more than sometimes had help from their mathematics teacher (*Teacher Support*) and they knew what they were supposed to complete in mathematics classes (*Task Orientation*). They "sometimes" experienced cooperation with their peers (*Cooperation*) and carried out inquiry mathematics activities in lessons (*Investigation*). The item with the lowest mean was *Involvement* (2.80). It seems that they seldom explained their solutions or participated in discussions during mathematics lessons. Indeed, their attitudes towards mathematics were also not very positive as the means for the *Confidence* and *Motivation* scales were close to 3.

Table 3
Item means and standard deviations for WIHIC and attitudes scales

Scale	No. of items	Item Mean ± SD
Student Cohesiveness	6	3.93 ± 0.79
Task Orientation	6	3.39 ± 0.72
Teacher Support	4	3.39 ± 0.83
Cooperation	6	3.25 ± 0.72
Investigation	5	3.04 ± 0.72
Involvement	4	2.80 ± 0.72
Motivation	5	3.08 ± 0.77
Confidence	5	3.05 ± 0.82

Gender and grade differences in perceptions of mathematics classroom environment

A two-way MANOVA, using the six WIHIC scales as the dependent variables and with gender and grade as the independent variables, yielded significant main effects for gender (Wilks' lambda = 0.948, F [6, 2503] = 23.02, p < .001) and grade (Wilks' lambda = 0.937, F [12, 5006] = 12.27, p < .001). There was no significant interaction between gender and grade (Wilks' lambda = 0.992, F [12, 5006] = 1.72, p = .056). As this interaction between gender and grade was not significant, *t*-test was conducted to examine gender differences and one-way MANOVA to examine grade differences. As shown in Table 4, gender differences in perceptions were found in five of the WIHIC scales, with the exception of *Task Orientation.* Girls perceived more cohesiveness among their classmates and had more opportunities working cooperatively mathematics classes than boys. On the other hand, boys perceived more opportunities in carrying out mathematics inquiry activities and were more mathematically involved than girls.

Table 4
Gender differences for WIHIC scales

Scale	Boys	Girls	*t*-value
	Item Mean ± SD	Item Mean ± SD	
Student Cohesiveness	3.88 ± 0.79	3.97 ± 0.76	-3.025**
Task Orientation	3.39 ± 0.72	3.38 ± 0.72	0.169
Teacher Support	3.43 ± 0.80	3.36 ± 0.85	2.003*
Cooperation	3.20 ± 0.75	3.29 ± 0.71	-3.168**
Investigation	3.13 ± 0.73	2.96 ± 0.71	5.865***
Involvement	2. 89 ± 0.71	2.73 ± 0.73	5.490***

Note: *< .05 **< .01 ***< .001

Table 5 shows that statistically significant differences were found by grade levels for all the six WIHIC scales. Scheffe's post hoc tests were was then used to examine differences between grades. Grade 10 students had the least favorable perceptions of their mathematics classroom environment, while Grade 11 students had the most favorable perceptions. In particular, Grade 10 students perceived that they had the least opportunities to carry out inquiry activities, to be involved in mathematical discussions, and had least support from their teachers.

Table 5
Grade differences for WIHIC scales

Scale	Grade 10	Grade 11	Grade 12	*F*
	Item Mean ± SD	Item Mean ± SD	Item Mean ± SD	
Student Cohesiveness	3.84 ± 0.77	4.01 ± 0.76	3.93 ± 0.81	12.066***
Task Orientation	3.35 ± 0.71	3.47 ± 0.70	3.34 ± 0.77	9.001***
Teacher Support	3.21 ± 0.84	3.54 ± 0.78	3.43 ± 0.81	40.800***
Cooperation	3.19 ± 0.71	3.34 ± 0.73	3.21 ± 0.73	12.144***
Investigation	2.93 ± 0.70	3.14 ± 0.72	3.03 ± 0.74	20.290***
Involvement	2.64 ± 0.73	2.97 ± 0.70	2.80 ± 0.70	52.947***

Note: ***< .001

Associations between mathematics learning environment and mathematics attitudes

The bivariate Pearson correlation coefficients in Table 6 were positive and statistically significant. The squares of the multiple correlation coefficients between the WIHIC scales and Confidence and Motivation were also statistically significant. These results show positive associations between classroom learning environment and students' attitudes towards mathematics. In particular, students' attitudes towards mathematics were likely to be positive in classes where they had greater opportunity for investigation and knew what they were supposed to complete.

Table 6

Simple correlations and multiple regression analysis between WIHIC and attitude scales

WIHIC scales	Attitudes			
	Confidence		*Motivation*	
	r	*β*	*r*	*β*
Student Cohesiveness	0.056**	-0.013	0.070***	-0.024
Teacher Support	0.082***	0.048	0.104***	0.003
Involvement	0.173***	0.097**	0.141***	-0.024
Investigation	0.193***	0.123***	0.214***	0.173***
Task Orientation	0.177***	0.113***	0.191***	0.119***
Cooperation	0.107***	-0.055	0.135***	-0.013
R^2		0.223***		0.231***

Note: **< .01 ***< .001

Discussion

This study was undertaken under the current mathematics curriculum reform in China to investigate mathematics classroom learning environment as perceived by senior secondary school students and the association of learning environment with students' mathematics attitudes toward mathematics. The students were found not to have positive attitudes towards mathematics, and they did not perceive their mathematics learning environment very favorably. In particular, they perceived that they did not often discuss or explain their thinking and answers, and carry out inquiry mathematics activities in their lessons. This lack of students' explaining and exploratory activities may reflect that mathematics teaching at senior secondary school level in China is dominated by the teacher as described in previous studies (e.g., Biggs, 1998; Huang et al., 1998; Leung, 2001).

Even though the objectives of the latest reformed senior secondary school mathematics curriculum are to develop in students the ability to articulate and communicate mathematical ideas and to foster students' interest and confidence in learning mathematics, these ideas may not have been achieved in practice. One main reason might be the pressure of examinations, as the Chinese education system has long been characterized as highly examination oriented (Cai & Nie, 2007; Li, 2006; Shao et al., 2012). Under the Chinese 6 + 3 + 3 education system, Grade 12 students need to take the College Entrance Examination, which is the most competitive examination in China since only a small proportion of students will pass it. The examination grades will determine the kind of university and even future careers of the students (Cai & Nie, 2007). Under such enormous pressure, the principal purpose of mathematics instruction, especially at the senior secondary school level, is to help students master the knowledge and skills to solve different types of mathematics problems (Li, 2006; Wang & Cai, 2007). A popular Chinese teaching method to meet this goal is described as “concise lecture with extensive practice,” which refers to teachers’ effective and precise explanations and the emphasis of students’ practice (Shao et al., 2012). Thus, instead of providing students the opportunities to discuss ideas with their peers, articulate their thoughts or solutions, and carry out mathematics inquiry activities, mathematics teachers in China tend to spend a lot of time on practice and students will work on the exercises individually without any discussion with their peers (Mok & Lopez-Real, 2006).

As in previous studies (e.g., Goh & Fraser, 1998; Waxman & Huang, 1998), gender-related differences were found in this study. However, unlike the findings in these other studies, girls in this study did not generally perceive their classroom learning environments more favorably than boys. The boys tended to perceive more involvement and more opportunities to carry out inquiry activities than girls, which is similar to the findings found in other contexts (e.g., Taylor & Fraser, 2013). These gender differences may be due to differences in mathematics learning styles. For example, in a recent survey of senior secondary school students in China, Zhang (2011) found that female students tend to copy their teachers’ solutions, and when they did not know how to solve a problem, they sought help from their teachers. On the other hand, male students tried to solve the problems by themselves and would explore by themselves when they encountered difficult problems. This provides evidence to explain the gender differences mentioned above.

Significant differences were found among students in different grade levels. However, not as anticipated, Grade 10 students perceived their mathematics classroom learning environment the least favorably, while Grade 11 students held the most favorable perceptions. The main reason may be the pressure of trying to complete the five compulsory modules in Grade 10 and earlier semester of Grade 11, leaving the four elective modules for Grade 11. Senior secondary school mathematics teachers across the country have reported that they do not have enough time to finish all the content within the short given time in Grade 10 (Tu, 2007). Thus, Grade 10 teachers will employ more directive teaching. In contrast, the pressure to complete the elective courses in Grade 11 is less. Finally, given the need to prepare Grade 12 students for the College Entrance Examination, teachers will stress knowledge and problem solving (Zheng, 2006), and this may lead Grade 12 students to have less favorable perceptions of their classroom learning environment than Grade 11 students.

The positive and significant associations between perceptions of mathematics classroom learning environment and confidence and motivation in mathematics are consistent with previous findings (Fraser, 2007, 2012). From this study, in particular, *Investigation* and *Task Orientation* were two statistically significant predictors of the two attitudes scales. This suggests that in classrooms where students know what they are supposed to do and have more opportunities to explore by themselves, they tend to hold more positive attitudes towards mathematics. The less than positive attitudes mathematics among Chinese students as reported in international comparative studies (Leung, 2006) might be influenced by and formed in the classes without many opportunities to carry out inquiry activities.

Conclusions, Implications, and Recommendations

This study found less than favorable perceptions held by senior secondary school students in six provinces in China about their mathematics classroom learning environment under the mathematics curriculum reform in China, although gender and grade differences in these perceptions were identified. They also did not hold positive attitudes towards mathematics. There were positive associations between these perceptions and attitudes towards mathematics.

This study contributes to the field of classroom learning environment research, and it extends the widely used instrument WIHIC to Chinese mathematics education. The findings reported here can provide information for researchers to understand and interpret Chinese mathematics education from the students' perspective, especially at the senior secondary school level, which has not been widely investigated. The findings shed light on why the outstanding performance Chinese students are not accompanied by positive attitudes towards mathematics. Even though ideas such as students' discussion and positive attitudes are emphasized under the reformed mathematics curriculum, in practice, these might not have been effectively implemented. These findings can suggest modifications of the mathematics curriculum for the future in China. Hopefully, this study may further stimulate comparative study of mathematics learning environments in China and other cultural contexts. Findings of the comparative studies can contribute to the understanding of how a particular social and cultural context influences its mathematics learning environment and how the learning environment affects students' mathematics affective learning outcomes.

This study has some limitations. First of all, the academic achievement of the participants was not obtained in the study. Future studies may investigate the associations between classroom learning environment, attitudes towards mathematics, and mathematics achievement. Findings derived from such studies might help educators to interpret the paradoxical situations mentioned above. Another limitation was that all the participants in the study were from urban schools. Future studies may include participants from rural schools to enhance the generalization of the findings. Other factors such as class size and streaming by subject choice (science stream and social science stream) may be included.

Acknowledgement

This study was supported by National Social Science Foundation for Young Scholars of China (Grant No. CHA 110133).

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