MATH ANXIETY QUESTIONNAIRE FOR CHINESE HIGH SCHOOL STUDENTS: A VALIDATION STUDY

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This study was conducted to validate Math Anxiety Questionnaire for Chinese High School Students (MAQ-CHSS), a self-developed content-based math anxiety questionnaire. Data was collected from 638 Chinese high school students at Grade 12 online and analysed using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA revealed that four of the five components (i.e. math test anxiety, numbers and operation anxiety, algebra anxiety, geometry anxiety, and statistics and probability anxiety) could be retained, the follow-up CFA exhibited adequate psychometry properties in the remaining 20 items. It was also found that girls experienced significantly higher levels of math test anxiety and geometry anxiety than boys. The validated questionnaire provides reliable psychometric tools for assessing high school students' math anxiety in the Chinese context.

INTRODUCTION

Researchers in mathematics education have paid great attention to math anxiety which is a negative learning experience for students. The uncomfortable experiences brought about by math anxiety can lead to maladaptive learning, procrastination, effortless or conservative learning strategies for math, and even giving up math learning. Math anxiety is a global issue (Organisation for Economic Cooperation and Development (OECD), 2013), and students from Asian countries often reported higher levels of math anxiety (Zhang et al., 2019). Chinese students were no exception. A report from the National Assessment Center for Education Quality (2018) revealed that about 40% of eighth-grade Chinese students experienced high-level math anxiety. Chinese high school students are under great pressure to prepare for the National College Admission Examination (NCAE) in which mathematics is one of the three core subjects that all students are required to take (Jiang et al., 2019). Therefore, they might encounter a higher level of math anxiety. That is why the current study was intended to target this group of students.

Math anxiety was studied as a single construct like Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972) and Math Anxiety Questionnaire (MAQ) (Wigfield & Meece, 1988). MARS was developed based on a mathematical task-based framework, while MAQ was emotion-based. Math anxiety was also studied as a sub-construct in questionnaires like the Motivated Strategies for Learning Questionnaire (Pintrich & De Groot, 1990). However, there were no questionnaires measuring math anxiety of high school students from both task-based and emotion-based perspectives. Therefore, the authors of this paper developed the Math Anxiety Questionnaire for Chinese High School Students (MAQ-CHSS), which integrated the task- and emotion-based frameworks, and intended to be validated with the twelfth-grade Chinese students.

In particular, this study was intended to address the following research questions: (a) Does the self-developed MAQ-CHSS have good reliability and validity? (b) What is the latent factor structure of the MAQ-CHSS? And (c) Are there any gender differences in math anxiety among Chinese high school students?

METHODS

Participants. The participants were 638 Grade-12 students from three schools in Zhuhai, Guangdong, 46.7% males and 53.3% females. Their average age was 17.29 years old, with a standard deviation 0.659.

Instruments: MAQ-CHSS. The MAQ-CHSS was developed in three steps. First, we examined the examination syllabus for math tests in NCAE (NEEA, 2019) and prepared a list of topics that were potentially to be covered in the math tests. Second, we did an analysis of the open-response items, which normally carried more scores and were taken as more important than other items, included in math test of NCAE in 2017-2021 and obtained the list of important topics in four content areas (i.e., numbers and operations (NO), algebra (AL), geometry and measurement (GM), and statistics and probability (SP)). Third, eight items were developed for each area with four related to the negative affective reaction component and four to the worry component. In a similar way, an eight-item math test anxiety was developed. The 40 items were combined together to form the MAQ-CHSS. For each item, a 4-point Likert scale ranging from 1 (Not at all true for me) to 4 (Very true for me) was used.

Data collection. The questionnaire was put into Tencent Questionnaire. All the items were set as compulsory so that there are no missing data. The link was sent to mathematics teachers of the participants.

Data analysis. To examine the reliability and validity of *MAQ-CHSS*, the following analysis were conducted: (a) descriptive statistics of all the items to test their normality; (b) Cronbach's alpha coefficient for the whole questionnaire and its sub-scales; (c) EFA to explore the factor structure of the questionnaire; (d) CFA to test the good fitness of the questionnaire with remaining items; and (e) independent sample t-tests to test the gender differences.

RESULTS

Descriptive Statistics. Their means ranged from 2.32 to 3.07 and SDs from 0.813 to 0.948. They were all normally distributed based on the criteria suggested by Kline (2015). Item 65, a reversed-coded item whose item-total correlation coefficient value was lower than 0.2, was excluded from the remaining analysis for its potential inconsistency with other items (Field, 2013).

EFA. A pre-factor analysis procedure revealed that items in numbers and operation anxiety were randomly loaded with all five factors (the first six eigenvalues were 20.087, 1.953, 1.569, 1.281, 1.175 and .964). However, these factors failed to adequately explain the anxiety types. Therefore, they were removed and a new round of EFA was conducted on the remaining 32 items. The value of Kaiser-Meyer-Olkin was .956, while the Bartlett's test of sphericity was significant, showing an approximate chi-square of 8462.221 ($p < .001$). These results indicated that the data were suitable for factor analysis.

EFA was then formally conducted on the remaining 32 items. Items 101, 84, 99, 74, 72, 95 and 87 were eliminated for cross-loading reasons, Items 93, 102, 94 and 66 were excluded because their item loading values did not match the practical assumption. For example, Item 93 under algebra was sorted to Factor 2 (math test anxiety). Furthermore, item 96 was also removed for its factor loading value was lower than 0.32. As a result, 20 items were retained (Table 3), with the four factors showing 69.8% of the total variance. Table 1 shows the standardised factor loadings of the remaining 20 items in MAQ-

CHSS. Table 2 shows the correlation coefficients among the four factors. The coefficients ranged from 0.522 to 0.729.

Item	Algebra anxiety	Math test anxiety	Geometry anxiety	Statistics and probability
89	0.801			
91	0.795			
86	0.751			
90	0.748			
103	0.574			
81		0.863		
77		0.768		
85		0.636		
92		0.569		
78		0.463		
82		0.448		
83			0.776	
98			0.756	
88			0.748	
73			0.667	
68				0.879
67				0.655
70				0.651
75				0.611
64				0.533

Table 1: Standardised Factor Loadings of the MAQ-CHSS

| Factor	1	2	3	4
1. Algebra anxiety	1			
2. Math test anxiety	0.729	1		
3. Geometry anxiety	0.662	0.650	1	
4. Statistics and probability anxiety	0.646	0.626	0.522	1

Table 2: Factor Correlation Matrix of the MAQ-CHSS

Reliability. All the variables on the MAQ-CHSS exhibited good reliability. The overall Cronbach's alpha was 0.952, while the subscales of the Cronbach's alphas were 0.912 for math test anxiety, 0.905 for algebra anxiety, 0.867 for geometry anxiety, and 0.821 for statistics and probability anxiety.

CFA. The first-order correlated factor model was operated on Amos (Figure 1). The model not only showed a good Bayesian information criterion value but also exhibited a good fit with RMSEA = 0.083 (90% CI, 0.075 to 0.091), TLI = 0.908 and CFI = 0.920.

Gender Differences. Table 3 shows the means and standard deviations of boys and girls in the four math anxiety aspects. Independent samples t-tests were conducted to explore the gender differences. It was found that girls reported a higher level of math anxiety in math test anxiety ($p < 0.01$) and geometry anxiety ($p < 0.01$).

CONCLUSIONS, DISCUSSIONS, AND IMPLICATIONS

This study was conducted to validate the MAQ-CHSS, which was self-developed based on the affection-worry emotional construct (Wigfield & Meece, 1988), the examination syllabus of math test in NCAE and an analysis of the items in math tests in NCAE in 2017-2021. The EFA and CFA results revealed a satisfactory reliability and validity.
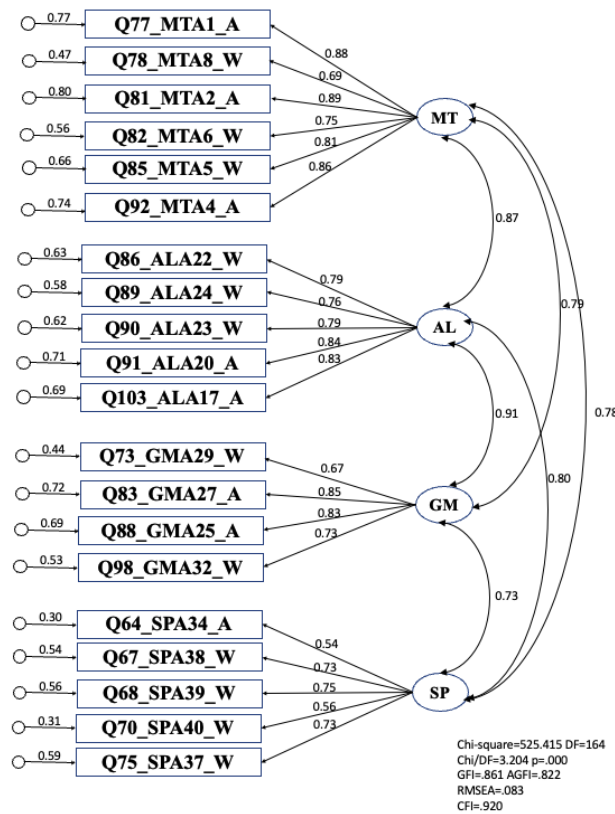
Notes. MT = Math test anxiety, AL = Algebra anxiety, GM = Geometry anxiety, SP = Statistics and probability anxiety.

Figure 1: The MAQ-CHSS Model

	Male	Female	t
Math test anxiety	2.62 (.762)	2.78 (.706)	-2.83**
Algebra anxiety	2.45(.796)	2.56(.724)	-1.81
Geometry anxiety	2.46(.787)	2.62(.712)	-2.58**
Statistics and probability anxiety	2.62(.689)	2.63(.584)	-0.19

** $p < .01$.

Table 3: Means and SDs of Math Anxiety between Male and Female

EFA showed that the "numbers and operation anxiety" items should be eliminated because they were randomly loaded with all five factors in the pre-factor analysis procedure. This happened probably for two reasons: a) The topics in numbers and operations are often taken as basic mathematical skills needed for solving problems in other content areas like algebra. b) The items in this content area were not difficult for the participants who were twelfth grade students having mastered the skills to solve them (Jiang et al., 2019).

Moreover, algebra anxiety is a reality. Although Trezise and Reeve (2017) stated the difficulties involved in measuring math anxiety in the algebra domain, the MAQ-CHSS makes the estimation possible by constructing items specifically related to the algebraic topics covered in NCAE examination syllabus.

In addition, gender differences were detected in math test anxiety and geometry anxiety. The girls reported a higher level of math test anxiety than the boys, which is consistent with the findings from previous studies.

In conclusion, the content-based MAQ-CHSS could be a reliable measure of high school students' anxiety in math test, algebra, geometry, and statistics and probability areas. Further studies could be conducted to investigate its correlations with students' mathematics performance in different content areas.

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