

Chinese High School Students' Mathematics-Related Beliefs and Their Perceived Mathematics Achievement: A Focus on Teachers' Praise

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ABSTRACT

This study examined the relationships between mathematics teachers' praise and students' mathematics-related beliefs and their perceived mathematics achievement rank in their respective classes. This study provided reliability and validity information about an instrument to assess high school students' mathematics beliefs. Students' mathematics-related beliefs are positively related to teachers' praise, as well as students' perceptions of their own achievement rank in their respective classes. While it was found that the proportion of students who reported that their teachers praised them was relatively low (about 28%), the more praise teachers provide, the more desirable mathematics-related beliefs students have. In addition, the more praise teachers provide, the higher students perceived achievement. The findings of this study suggest that teachers' praise may foster more desirable mathematics-related beliefs and achievement.

Keywords: China, mathematics, students' mathematics-related beliefs, teacher praise

INTRODUCTION

Students' beliefs related to mathematics have long been an important topic of study in mathematics education, both because of their relationship to affect and motivation (McLeod, 1992; Middleton, Jansen, & Goldin, 2017) and because of their potential influence on students' mathematical thinking and activity (Schoenfeld, 1989, 1992). Indeed, the teaching and learning of mathematics necessarily involves affective and noncognitive considerations including beliefs, emotions, values, and attitudes (Cai et al., 2017; Clarkson, Bishop, & Seah, 2010; Leder, 1993; Moyer, Robinson, & Cai, 2018; Pepin & Roesken-Winter, 2015). Op't Eynde, De Corte, and Verschaffel (2002) developed a comprehensive categorization of mathematics beliefs: beliefs about mathematics education, beliefs about the self, and beliefs about social context. Each of these categories of mathematics-related beliefs is potentially related to students' mathematical behavior.

Moreover, mathematics-related beliefs have been studied as predictors of students' mathematical achievement (House, 2009; Lay, Ng, & Chong, 2015). Given the potential ways in which mathematics-related beliefs both influence and are influenced by factors, such as mathematics achievement and interactions with parents and teachers, it is hardly surprising that students' mathematics-related beliefs are increasingly emerging as an important topic in the international mathematics education research community. Studies have shown that teachers' behaviors have an effect on educational aspirations, cognitive ability, mathematics achievement, mathematics learning, motivational beliefs about mathematics, mathematical self-efficacy, and so forth (e.g., Levpušček & Zupančič, 2009; Phillipson, 2010; Zijlstra, Wubbels, Brekelmans & Koomen, 2013). However, there has not been a systematic body of research focusing on the influence of factors such as teachers on students' mathematics-related beliefs.

Students in East Asian countries and regions have excelled in large-scale international academic assessments such as TIMSS and PISA. Studies have shown that this has a certain relationship with the performance of teachers

Contribution of this paper to the literature

- Provides a valid and reliable instrument to assess Chinese students' mathematics-related beliefs.
- Students' mathematics-related beliefs are positively related to teachers' praise, as well as students' perceptions of their own achievement rank in their respective classes.
- While it was found that the proportion of students who reported that their teachers praised them was relatively low (about 28%), the more praise teachers provide, the more desirable mathematics-related beliefs students have.
- The more praise teachers provide, the higher students perceived achievement.
- The findings of this study suggest that teachers' praise may foster more desirable mathematics-related beliefs and achievement.

(Phillipson & Phillipson, 2007). China is a typical representative of the Confucian Heritage Culture (CHC) countries (Fan, Wong, Cai, & Li, 2004) which exhibit these culturally situated factors. The research reported here was designed to investigate the current status of mathematics-related beliefs among Chinese senior high school students, to analyze the influence of Chinese teachers on the beliefs of high school students in mathematics, and to provide a reference point for education in other countries and regions.

In particular, this study is designed to investigate the following two research questions:

- 1) How are teachers' appraisals related to students' mathematics-related beliefs and their perceived mathematics achievement?
- 2) How are students' mathematics-related beliefs related to their perceived achievement?

THEORETICAL BASES

Teacher Interpersonal Behavior

Early research showed that when students feel that their teachers value, care for, and support them, they are more likely to have higher motivation for academic achievement (Goodnow, 1993; Wentzel, 1997). Patrick, Ryan, and Kaplan (2007) pointed out that such support includes the teacher caring about students' learning, trying to help them learn, and encouraging them to do their best. In addition, some studies have shown that teacher care (teacher support) has a significant effect on students' academic performance after controlling for family factors (Marchant, Paulson & Rothlisberg, 2001). Indeed, Levpušček and Zupančič (2009) found that the support and encouragement of mathematics teachers had an even greater impact on students' mathematics achievement than parental education, although they noted that "the combined effect of both student-rated family and classroom context on eighth graders' math performance is stronger than the effect of either context alone" (p. 563).

Based on the existing research, Lapointe, Legault, and Batiste (2005) further explored the influence of teacher interpersonal behavior on students' mathematics learning motivation and found that mathematics teachers' interpersonal relationship behaviors have a significant effect on both regular students and students identified as talented. Zijlstra, Wubbels, Brekelmans, and Koomen (2013) investigated the relationship between 6-9 year-old students' perceptions of teacher interpersonal behavior and achievement in mathematics and found that students' views on mathematics teachers' control and connection were important predictors of student achievement in mathematics.

In summary, the existing studies mostly examine the effects of the behavior of teachers on overall mathematics academic achievement and mathematics learning motivation but have not paid detailed attention to the influence of mathematics teacher behavior on students' mathematics-related beliefs (although see the discussion of Levpušček & Zupančič, 2009, about the mediating role of self-efficacy between parental and teacher influences and mathematics achievement). The present study focuses in particular on the encouragement of mathematics teachers' evaluative speech, specifically the influence of mathematics teachers' praise on students' mathematics-related beliefs. Based on the existing research, it is assumed that positive recognition by the mathematics teacher has a positive influence on students' mathematics-related beliefs, and that its influence may be greater than parental education expectations.

Mathematics Achievement and Self-Efficacy

A large number of studies have shown that there is a significant correlation between student mathematics-related beliefs and student mathematics achievement (e.g., House, 2009; Lay, Ng, & Chong, 2015). These studies typically use students' mathematics achievement as a dependent variable and some particular student mathematics-related beliefs, including beliefs about mathematics self-efficacy, as predictors. For example, Skaalvik

Table 1. Participants' Background Information

	Number of participants	%
Gender		
Male	250	50.4
Female	246	49.6
Grade		
10	265	53.4
11	136	27.4
12	95	19.2

and Skaalvik (2011) explored the relationship between mathematics self-concept and self-efficacy and mathematics achievement. They found that students' self-efficacy was a strong predictor of achievement even beyond prior achievement. Pantziara (2016) noted, however, that few of these studies "provide causal ordering between the two constructs" (p. 8) of mathematics self-efficacy and mathematics achievement. Nevertheless, House (2009) concluded after a series of studies that students with better mathematics performance tend to have more positive mathematics-related beliefs, and those with poor mathematics performance have more negative mathematics-related beliefs. In other words, students' academic achievement in mathematics may have a positive effect on students' mathematics-related beliefs and vice versa.

In this study, the students' perception of their relative mathematics achievement ranking in their class is used as the measure of student achievement, and we assume that the students' perceived class mathematics achievement ranking may have a positive influence on their mathematics-related beliefs (and vice versa). In a study of mathematics students in Finland, Hannula, Bofah, Tuohilampi, and Metsamuuronen (2014) found that mathematics achievement and self-efficacy had a reciprocal relation, where the dominant effect was from achievement to self-efficacy. They also found a weaker unidirectional effect from achievement to emotion. Cai and Merlino (2011) also found that students' success in mathematical achievement was linked to positive mathematical dispositions. Students who succeeded in the process of learning mathematics through concerted effort in overcoming challenges gained a sense of satisfaction that bolstered their motivation to continue challenging themselves in mathematics. Cai and Merlino (2011) posited that this could produce a positive disposition-performance cycle.

METHOD

Participants

A survey was administered nationwide using a combination of online sampling and regional cluster sampling. The survey began with regional cluster sampling, and this was followed by an online sampling to ensure a high response rate. In total, 496 valid questionnaires were collected. The participants came from the following parts of China: Central China, North China, East China, South China, Northwest China, Northeast China and Southwest China. The background information of the participants is shown in [Table 1](#).

Instrument

The survey instrument was adapted from a questionnaire originally developed by Op't Eynde and De Corte (2003). Because PISA and TIMSS are international assessment projects that include items related to mathematics beliefs, we also drew on those assessments in the development of the questionnaire. However, although we included items drawn from PISA and TIMSS, the instrument developed by Op't Eynde and De Corte had useful theoretical properties with respect to beliefs subscales. Thus, we made use of this theoretical structure by adopting the first three of the four subscale categories established by Op't Eynde and De Corte. We focused our fourth subscale on mathematics anxiety, using items from TIMSS.

The survey instrument underwent three stages of revision and refinement before being used in this study. In each stage, a group of mathematics education researchers have served as expert to ensure the content validity. In this section, we discuss the process of developing the Chinese version of the instrument.

The preliminary edition and its piloting

The Students' Mathematics-Related Beliefs Questionnaire (SMRBQ) compiled by Op't Eynde and De Corte (2003) was revised for use with Chinese high school students. We called the revised instrument the High School Student Mathematics Belief Questionnaire. The English version of the SMRBQ was translated into Chinese and then translated back into English by graduate students with good English language skills. We revised the Chinese version by comparing the result with the original English version. Taking into account applicability under the

background of Chinese mathematics education and the accuracy of the terms in the questionnaire, combined with the characteristics of mathematics studying of Chinese high school students, and drawing on the PISA-2012 background questionnaires and the TIMSS-2015 background questionnaires on student mathematics-related belief items, we added or deleted some items, eventually forming the preliminary draft of a mathematics-related belief questionnaire with 52 items for high school students. The preliminary draft of the questionnaire retained three of the four subquestionnaires included in the original questionnaire. These were 1) beliefs about the role and the functioning of their own teacher, 2) beliefs about the significance of and competence in mathematics, and 3) mathematics as a social activity (Op't Eynde & De Corte, 2003). The preliminary draft also included items, primarily from TIMSS-2015, comprising a fourth subquestionnaire that focused on mathematics anxiety. All 52 items were randomly arranged. Nine of the items were scored in reverse.

The preliminary edition of the questionnaire was piloted with 190 students in two high schools of Tianjin City. In total, 182 responses were collected, and 174 valid responses were examined with item analyses. The participants in the pilot were 80 boys and 94 girls; 61 students were in 10th grade and 113 students were in 11th grade. The pilot data were used to examine the clarity of the language used in the items. The questionnaire was revised based on the pilot data. In particular, based on the analysis of results from piloting, the feedback from the subjects, and the suggestions of the in-service secondary mathematics teachers, the following changes were made: two items were deleted because they did not achieve significant differences between the high and low groups; one item was deleted because the Critical Ratio was low; and regarding the item, "I need mathematics to help me learn other subjects," we added examples such as "Physics, Geography, and so forth" to the text of the item in order to make the questionnaire easier for high school students to understand. Thus, the second edition of the questionnaire contained 49 items and had the same structure as the initial draft questionnaire.

The second edition and its validation

The second edition of the questionnaire was administered in 13 secondary schools from nine cities in China. In total, 960 questionnaires were distributed, 936 were returned, and 902 were valid. Through item analysis and exploratory factor analysis, we deleted those items which did not meet the psychometric criteria (with low loading). The participants in this second round were 460 boys and 448 girls; 402 were in 10th grade, 356 were in 11th grade, and 150 were in 12th grade.

Based on the total scores of students' mathematics-related beliefs, the top 27% were considered the high score group and the bottom 27% the low score group. The independent samples t test was conducted for the scores on each item for the high and low score groups, and a correlation analysis was also implemented between all the items and the total scores of each subquestionnaire. The deletion criteria for the correlation coefficient between all items and the subquestionnaire was set at 0.40. One item with insignificant t value and 3 items with correlation coefficients less than 0.40 were deleted, and 45 items were retained. The correlation coefficients between the scores from the 45 items and the total score of the subquestionnaires was distributed between 0.45 and 0.85 (all $p < 0.001$).

An exploratory factor analysis was conducted on the remaining 45 items. The results indicated that the KMO values of each subquestionnaire in the exploratory factor analysis ranged from 0.82 to 0.95, and Bartlett's sphere test reached a significant level ($p < 0.001$). The results revealed that each subquestionnaire was suitable for the factor analysis.

According to the research objectives and theoretical conceptions, after the first factor analysis of each subscale, we first deleted the items with the highest load on the other extracted factors and then conducted factor analysis again, so that the item-by-item deletion was performed successively for a series of factor analyses until the final extracted factors were in line with the theoretical conceptions. In the end, the entire questionnaire retained 40 items, and the load of factors for each item on the subscales ranged from 0.57 to 0.89. The explained variation ranged from 54.83% to 61.49%.

The Cronbach's α coefficients of the subscales and the α coefficients of the 40 items were examined. The results showed that the α coefficient after the two items in the subscale of Beliefs about the significance of and competence in mathematics had been deleted was 0.934, and the α coefficient after an item in the subscale of Mathematics as a social activity was deleted was 0.882, both of which were greater than the Cronbach's α coefficients of the respective subscale. The α coefficient of the Beliefs about the role and the functioning of their own teacher is equal to the Cronbach's α coefficient of the subscale, which indicates that after the deletion of the item, the reliability of the subscale was not changed. Finally, 36 items were retained.

The scores of students' mathematics-related beliefs were ranked. The top 27% were considered the high score group and the bottom 27% the low score group. The scores of high and low groups on each item were tested by independent samples t test. The results showed that the high score group's scores on the 36 items were significantly different from the low score group's scores, and all items had good discrimination.

Table 2. Goodness of Fit of Four-Factor Model for the High School Students Mathematics Belief Questionnaire

χ^2	df	NC	RMSEA	GFI	AGFI	PGFI	CN
1200.66***	629	1.91	0.05	0.82	0.80	0.73	209

Note: *** $p < .001$

Table 3. Correlation Coefficients of the High School Students Mathematics Belief Questionnaire, the IMBS Subscale of Time-consuming Mathematics Problem Solving, and FSMAS

	Subscale 1	Subscale 2	Subscale 3	Subscale 4	Overall scale	IMBS	FSMAS
Subscale 1	1						
Subscale 2	0.58***	1					
Subscale 3	0.61***	0.53***	1				
Subscale 4	0.36***	0.34***	0.31***	1			
Overall	0.82***	0.91***	0.81***	0.76***	1		
IMBS	0.28***	0.55***	0.33***	0.46***	0.52***	1	
FSMAS	0.44***	0.40***	0.53***	0.11***	0.49***	0.29***	1

Note: *** $p < .001$

The third edition and its reliability and validity

The third edition of the questionnaire was administered to students from five secondary schools in four cities. These schools did not administer the two earlier versions of the questionnaire. There were 370 questionnaires distributed; 362 were returned, and 351 of those were valid. We reconfirmed the factors through confirmatory factor analysis and obtained the reliability and validity indices. The participants in this round were 179 boys and 167 girls, with 5 participants missing a gender record; 109 were in 10th grade, 137 were in 11th grade, and 105 were in 12th grade.

The reliability analysis of the high school students' belief in mathematics questionnaire showed that the Cronbach's α coefficient of each scale was between 0.84 and 0.95 (see Table 4), the retest reliability was between 0.79 and 0.87, which are reasonably high.

With respect to the construct validity, a maximum likelihood method was used to perform a confirmatory factor analysis on the officially tested sample ($n = 351$). The four subscales were used to constitute a four-factor model. We selected χ^2 , NC, RMSEA, GFI, AGFI, PGFI, and CN as evaluation indicators for the fit of the model. The results are shown in Table 2.

For the fit of the hypothesis model, $\chi^2 = 1200.66$, $df = 629$, $p < 0.001$, and χ^2 reached a significant level, which does not meet the standard. However, χ^2 is susceptible to sample size and sample distribution, so this value is for reference only. NC (χ^2/df) = 1.91, which is between 1.00 and 3.00, indicating that the model's fit is high. Both PGFI = 0.73 > 0.50 and CN = 209 > 200 indicate that the four-factor model meets the fit criteria. Neither GFI nor AGFI reached the standard of 0.90, but Anderson and Gerbing (1984) advocated using 0.80 as the critical value for goodness of fit, so both GFI = 0.82 and AGFI = 0.80 are acceptable. RMSEA, as an indicator of noncentralized Chi-square indicators in the third category, which is not affected by sample distribution and sample size, is very suitable for estimating the power of statistical tests. The smaller the RMSEA value is, the better the fit of the model is. The RMSEA value of the four-factor model was 0.05, which means a good fit. In summary, the four-factor model fit index reached the basic standard.

For the criterion validity, the subscale of time-consuming mathematics problem solving and the mathematical usefulness attitude scale (FSMAS) in the Indiana Mathematical Belief Scale (IMBS) (Fennema & Sherman, 1976) were treated as criteria. There was a significant positive correlation between the scales (see Table 3). The correlation coefficients between the four subscales were between 0.31 and 0.61. The correlation coefficients between the four subscales and the overall scale were between 0.76 and 0.91. This shows that the four subscales are relatively independent and can make a greater contribution to the entire questionnaire. The overall questionnaire has good construct validity.

Measures

The revised High School Students Mathematics Belief Questionnaire was used to measure the levels of the students' mathematics-related beliefs. Four additional questions were included in the Questionnaire on High School Students' Belief in Mathematics to investigate mathematics teachers' praise, and mathematics achievement ranking in the class. Table 4 lists the questionnaire items used for these four topics.

Table 4. Four Additional Items from the Questionnaire

Topic	Questionnaire Item
Mathematics teachers' praise	Math teachers often praise me.
	1. Strongly disagree
	2. Disagree
	3. Neutral
	4. Agree
Students' perceived math achievement ranking in the class	What is your math achievement ranking in the class?
	1. High (top 10%)
	2. Upper middle (10% to 35%)
	3. Middle (35% to 65%)
	4. Lower middle (65% to 85%)
	5. Low (bottom 15%)

RESULTS

We present the results in three sections. The first section deals with relationships between students' mathematics-related beliefs and the measured factors regarding mathematics teachers' praise. The second section examines relationships between students' perceived mathematics achievement rankings in the class and mathematics teachers' praise. The third section deals with the relationship between students' perceived mathematics achievement rankings in the class and students' mathematics-related beliefs.

Mathematics-Related Beliefs and Teacher Praises

In order to examine the relationships between the mathematics-related beliefs scores (total and for each subscale) and teachers' praise, we conducted an ANOVA analysis for each factor and each belief score (total or subscale). **Table 5** shows the results for teachers' praise and students' mathematics-related beliefs. As indicated in **Table 5**, only about 28% (139 out of 496) of the students agreed or strongly agreed that their teachers gave them praise. In contrast, over one third of the students disagreed or strongly disagreed that their teachers gave them praise. Overall, the higher the degree of teachers' praise, the more positive the students' mathematics-related beliefs were. For example, the mean overall mathematics-related beliefs score for those students who strongly agreed that their teachers praised them was 147. However, the mean score for those students who strongly disagreed that their teachers praised them was 102. These findings for overall mathematics-related beliefs remained consistent across the first three subscales of mathematics-related beliefs. For the fourth subscale, the ANOVA analysis did not show a significant difference.

Table 5. Teachers' Praise and Students' Mathematics-Related Beliefs

	Teachers' Praise	Mean	SD	# of Students	F	η^2
Mathematics-Related Beliefs (total)	Strongly Disagree	102.2910	24.24269	61	51.008***	.294
	Disagree	114.6824	17.19791	110		
	Neutral	127.1509	18.01370	186		
	Agree	134.7883	15.92462	94		
	Strongly Agree	147.0222	25.59163	45		
Beliefs about the role and the functioning of their own teacher instruction	Strongly Disagree	39.9180	11.97956	61	45.216***	.269
	Disagree	45.1578	8.06569	110		
	Neutral	49.9856	8.05507	186		
	Agree	53.2522	6.70143	94		
	Strongly Agree	59.1556	9.37588	45		
Beliefs about the significance of and competence in mathematics	Strongly Disagree	27.8648	10.68291	61	33.072***	.212
	Disagree	31.6791	7.79893	110		
	Neutral	36.6707	7.85458	186		
	Agree	39.7275	7.84698	94		
	Strongly Agree	43.2667	11.43440	45		
Mathematics as a social activity	Strongly Disagree	20.0984	7.11502	61	29.369***	.193
	Disagree	23.0364	5.01544	110		
	Neutral	25.5538	4.52857	186		
	Agree	27.2447	4.35936	94		
	Strongly Agree	29.0889	6.60173	45		
Mathematics anxiety	Strongly Disagree	14.4098	6.14377	61	0.459n.s.	.004
	Disagree	14.8091	4.04900	110		
	Neutral	14.9409	4.26700	186		
	Agree	14.5638	4.08659	94		
	Strongly Agree	15.5111	6.55959	45		

Note: *** $p < .001$, n.s. $p > .05$

Table 6. Students' perceived class rank

Class Rank	Number of participants	%
High (top 10%)	41	8.3
Upper middle (10% - 35%)	119	24.0
Middle (35% - 65%)	158	32.1
Lower middle (65% - 85%)	108	21.8
Low (bottom 15%)	69	13.9

Perceived Mathematics Achievement and Teacher Praise

In addition to examining the relationships between the mathematics-related belief subscale scores and teacher praise, we also examined the relationships between the students' perceived mathematics achievement (reported as their perceived ranking in class) and teacher praise. **Table 6** shows the distribution of students' perceived mathematics achievement rankings in the class. A High class rank indicates that the subject's mathematics grades were generally in the top 10% of the class, Upper Middle represents a ranking from 10% to 35%, Middle means 35% to 65%, Lower Middle means a ranking of 65% to 85%, and Low indicates that the math grades are in the bottom 15%.

Chi-square tests were conducted to probe the relationships between students' perceived mathematics achievement and teacher praise. As **Table 7** shows, students' perceptions of their own class ranking were significantly associated with their reporting of receiving their teachers' praise. That is, there was a clear relationship between teacher praise and students' perceived achievement ranking in class.

Table 7. Teachers' Praise and Students' Perceived Achievement

		Mathematics teachers' praise					Total
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Students' Perceived Ranking in Their Respective Classes	Low	19	26	18	1	5	69
	Lower Middle	15	27	33	21	12	108
	Middle	12	36	70	36	5	159
	Upper Middle	12	16	50	30	11	119
	High	3	5	15	6	12	41
		$\chi^2 = 78.047^{***}$					

Note : *** $p < .001$ **Table 8.** Students' Perceived Achievement and Students' Math-Related Beliefs

	Perceived Achievement	Mean	SD	# of Students	F	η^2
Mathematics-Related Beliefs (total)	Low	108.3862	21.94739	69	29.507***	0.194
	Lower Middle	118.0581	22.48730	108		
	Middle	123.5675	20.06813	159		
	Upper Middle	134.9147	17.89734	119		
	High	142.9258	20.64717	41		
Beliefs about the role and the functioning of their own teacher instruction	Low	45.1978	10.65033	69	8.254***	0.063
	Lower Middle	47.6970	10.49410	108		
	Middle	48.7280	9.66997	159		
	Upper Middle	51.4177	8.61173	119		
	High	54.4146	8.38742	41		
Beliefs about the significance of and competence in mathematics	Low	27.2319	8.38266	69	47.681***	0.280
	Lower Middle	32.3148	9.13619	108		
	Middle	35.2420	8.06983	159		
	Upper Middle	41.0096	7.77585	119		
	High	44.7307	7.27783	41		
Mathematics as a social activity	Low	22.1159	5.24835	69	13.425***	0.099
	Lower Middle	23.7037	6.32346	108		
	Middle	24.7107	5.22330	159		
	Upper Middle	27.1933	5.01401	119		
	High	27.6098	5.87741	41		
Mathematics anxiety	Low	13.8406	5.59049	69	2.212n.s.	0.018
	Lower Middle	14.3426	4.61238	108		
	Middle	14.8868	3.88111	159		
	Upper Middle	15.2941	4.75564	119		
	High	16.1707	5.62095	41		

Note: *** $p < .001$, n.s. $p > .05$

Perceived Achievement and Mathematics-Related Beliefs

Finally, we examined the relationships between students' perceived mathematics achievement rankings and their mathematics-related beliefs. We carried out an ANOVA for perceived achievement and each of the belief subscale scores as well as the overall belief score (see Table 8). A statistically significant relationship was found for each of the belief scores except for the Mathematics anxiety subscale.

DISCUSSION

The goal of this study was to examine, in the context of Chinese high school students, the relationships between students' mathematics-related beliefs and teacher praise as well as students' perceptions of their own mathematics achievement in their classes. Using a framework derived from Op't Eynde and De Corte (2003) as well as relevant items adapted from TIMSS and PISA, we developed the High School Student Mathematics Belief Questionnaire to assess Chinese students' mathematics-related beliefs. The results of this study provide support in the context of Chinese secondary education for several findings from the literature on mathematics-related beliefs.

First, the results show that teachers' praise is positively related to Chinese high school students' mathematics-related beliefs. In other words, students who reported that their teachers praised them were more likely to possess

more desirable mathematics-related beliefs. This supports the finding of Levpušček and Zupančič (2009) regarding the importance for mathematics achievement of the support and encouragement that mathematics teachers can offer to students. It is notable, however, that in this Chinese sample, only a relatively small percentage (about 28%) of students reported that their teachers gave them praise. This is a surprisingly small percentage that leaves room to explore how increasing teacher praise might influence students' mathematical beliefs and achievement.

Second, students' reported mathematics achievement level in their classes was positively related to teacher praise. This is consistent with the findings of some studies (e.g., Phillipson, 2010; Rodríguez et al., 2017). The uniqueness of this study is that students' perceived mathematics achievement rank is quite consistent with the data.

Finally, math anxiety is something of an outlier among the four mathematics-related beliefs subscales in the sense that the relationship between this subscale is not correlated in the same way as the other subscales with the other variables. This finding could be interpreted as reflecting the possibility that a certain degree of math anxiety is a good thing for math learning. However, too low or too high a degree of math anxiety may not be healthy for students' math learning. Prior research on math anxiety has revealed that the relationships between math anxiety and achievement are exceedingly complex (Ma, 1999). Based on our findings in this study, we might hypothesize that neither too little anxiety nor too much anxiety produces a strong correlation with achievement. This suggests that a future direction for exploration would be to understand how much math anxiety is beneficial for supporting desirable math beliefs and achievement.

The findings of this study have implications for pedagogical practice. In order to help students develop desirable mathematics-related beliefs, teachers may be able to strategically use praise. In this study, over 70% of the students viewed that their teacher did not give them praise. This implies that there is quite a bit of room to increase praise to encourage more desirable beliefs. This study confirms the positive effects of mathematics teachers' praise on students' mathematics-related beliefs and achievement. This suggests that good communication between mathematics teachers and students could greatly benefit students' mathematics-related beliefs. However, blindly pursuing the delivery of children to prestigious classes in an effort to pressure them to academically perform in mathematics may result in comparatively poor mathematics grades, resulting in less desirable mathematics-related beliefs and further affecting students' mathematics self-efficacy and performance.

A limitation of this study is that it is based purely on survey data collected from students. Thus, information on teachers' praise is channeled entirely through the reporting of the students. A future study is needed to go beyond examining only students' perceptions about teachers' praise to also collect data directly from teachers, as well as to collect actual student mathematics achievement data.

Endnote

1. A series of multiple linear regression analyses were also explored for these data, with the total belief score and each subscale score as the dependent variable and the teacher praise as predictor. Given the categorical/ordinal nature of the teacher praise variable, these analyses did not illuminate the data beyond the ANOVA analyses (neither did they contradict the ANOVA findings). Thus, those results are not reported here.

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APPENDIX

High School Student Mathematics Belief Questionnaire

The questionnaire items listed below are grouped by subscale. The items' positions in the questionnaire as administered were randomized.

Subscale 1: Beliefs About the Role and Functioning of Their Own Teacher

- I am interested in what my teacher says in mathematics lessons
- My mathematics teacher is easy to understand
- The mathematics teacher asks me or my classmates to specify our thinking or reasoning
- The mathematics teacher asks questions to check whether we have understood what was taught
- The mathematics teacher gives students an opportunity to express opinions
- The mathematics teacher sets clear goals for our learning
- The teacher tells me what I need to do to become better in mathematics
- My mathematics teacher has clear answers to my questions
- At the beginning of a mathematics lesson, the teacher presents a short summary of the previous lesson
- Our mathematics teacher listens carefully when we ask or say something
- Our teacher explains why mathematics is important
- Our mathematics teacher appreciates it when we have tried hard, even if our results are not so good
- Our mathematics teacher gives us time to really explore new problems and to try out possible solution strategies

Subscale 2: Beliefs about the significance of and competence in mathematics

- I can understand even the most difficult material presented in a mathematics course
- Mathematics is one of my favorite subjects
- If I wanted to I could do better in mathematics
- I am good at working out difficult mathematics problems
- I enjoy learning mathematics

I learn high school mathematics quickly
I'm very interested in mathematics
I look forward to my mathematics lessons
It is important to learn mathematics
I need mathematics to learn other school subjects such as physics, geography, etc.
I like doing mathematics

Subscale 3: Mathematics as a social activity

Mathematics is benefit for human development
Mathematics is used by a lot of people in their daily life
Development of many disciplines depends on mathematics
I learn many interesting things in mathematics
I think I will be able to use what I learn in mathematics also in other courses
Mathematics enables men to better understand the world he lives in
I am willing to pursue a major in mathematics at university

Subscale 4: Mathematics anxiety

Mathematics is harder for me than any other subject
Mathematics is more difficult for me than for many of my classmates
I have no confidence in myself before learning new mathematics
High school mathematics makes me anxious
Mathematics is not one of my strengths

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