

A Comparative Study on Chinese Teachers' and Students' Beliefs about Mathematics, Mathematics Teaching and Learning in Middle School

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The paper used the quantitative method to compare Chinese students' and teachers' mathematics related beliefs, including beliefs about mathematics, mathematics teaching and learning. The result indicated that there are some differences between their beliefs. Based on the results, we give some recommendations.

Keywords: beliefs about mathematics, beliefs about mathematics learning, beliefs about mathematics teaching

ZDM Classification: C20, C30

MSC2000 Classification: 97C20, 97C30

INTRODUCTION

With the development of cognitive psychology, beliefs increasingly become concerned by the researchers. In mathematics education, beliefs generally include beliefs about mathematics, beliefs about mathematics teaching and learning. These beliefs, which together form a system, are interrelated to each other, and influenced by each other (Jin, 2001; Thompson, 1992).

Beliefs about mathematics are the individual views about nature of mathematics as a

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discipline; beliefs about mathematics learning are the individual views of the process of learning mathematics, what behaviors and mental activities, and what constitute appropriate and prototypical learning activities; beliefs about mathematics teaching are the individual views about the type and range of teaching roles, actions and classroom activities associated with the teaching of mathematics (Ernest, 1989).

Students' beliefs about mathematics, mathematics teaching and learning can determine how they choose to approach a problem, which techniques will be used or avoided, how long and how hard they will work on it, and so on (Op't Eynde & De Corte, 2003). Students' ways of tackling mathematics problems are constrained by what they see as mathematics problems and what they see as reasonable ways of going about solving such problems (Wong *et al.*, 2002). So they also can influence solving problems and achievement of mathematics (Liu & Chen, 2004; Schommer *et al.*, 2005; House, 2006; Chen, 2003; Chen, 2005; Wong *et al.*, 2002). Students' beliefs can influence their subjective initiative, and guide them to choose the appropriate cognitive strategies to solve mathematics problems.

With the experience of learning, mathematics teachers develop their own beliefs which directly or indirectly impact on their teaching (Li, 2001). Mathematics teachers' beliefs impact on their ways of teaching strongly, and guide their decisions in the classroom, and can influence many facets of classroom, including the degree of student autonomy and forms of assessment in the classroom (Correa *et al.*, 2006). Teachers' beliefs also affect the selection and use of materials (Handal B., 2003). Anyway, teachers' beliefs guide all aspects of teaching (Correa, 2008; Golafshani 2004; Raymond, 1993; Haser & Cigdem, 2006). Moreover, teachers' beliefs acted as a filter to new knowledge, accepting what was compatible with current beliefs (Jin, *et al.*, 2007).

Students and teachers are the two subjects in activities of teaching and learning mathematics. Teachers transfer their beliefs to students by activities of teaching, and then affect the formation of their beliefs. In turn, students' beliefs influence and restrict teachers' activities of teaching mathematics (Jin, 2001). In a word, beliefs of teachers and students are influenced by each other. This paper used quantitative method to investigate Chinese teachers' and students' mathematics-related beliefs, including the beliefs about mathematics, mathematics teaching and learning, and find the differences between them. The results are expected to promote the development of belief researches.

THE RESEARCH METHOD

Participants

We collected the data from 138 middle school students and 79 their mathematics

teachers in Liaoning Province.

Instruments

We have developed a 44-item questionnaire to investigate Chinese teachers' beliefs and students' beliefs about mathematics, mathematics teaching and learning. All of the 44 items were adapted from published studies that focused on teachers' or students' mathematical beliefs. The criteria were followed in selecting items: items had to fit within one of the three of beliefs about the nature of mathematics, mathematics learning, and mathematics teaching; items had to relate to the core issue of whether mathematics education should focus on understanding and problem solving or rote memorization and teaching students procedural skill.

The questionnaire consisted of three scales that are beliefs about mathematics, mathematics teaching and learning. Beliefs about mathematics scale was developed to survey their beliefs about nature of mathematics, relationships between mathematics and other subjects and life, and the values of it, including 13 items. Beliefs about mathematics teaching scale was developed to survey beliefs about mathematics problems solving, the role of understanding and exercises on learning, gift, hard working and group work, including 16 items. Beliefs about teaching mathematics scales was developed to investigate their beliefs about nature of teaching mathematics, the aims and focus of teaching, the task and authority of teachers, and instructional assessment, including 15 items (See Appendix A).

Reliability

Table1 shows the results of the reliability analysis of the subscales and the whole scale for the students' and teachers' beliefs questionnaire using the collected data. The Cronbach's α for the whole scale of students is 0.993, and teachers' is 0.993.

Table 1. Reliability of the students' and teachers' beliefs questionnaire

	Subtypes of beliefs	Number of items	Number of cases	Cronbach's Alpha
Student	Beliefs about mathematics	13	138	0.981
	Beliefs about mathematics learning	16	138	0.977
	Beliefs about mathematics teaching	15	138	0.982
	total	44	138	0.993
Teacher	Beliefs about mathematics	13	79	0.963
	Beliefs about mathematics learning	16	79	0.984
	Beliefs about mathematics teaching	15	79	0.986
	total	44	79	0.993

All the subscales demonstrated an acceptable level of reliability.

Data Analyses

The statistical software package, SPSS, is used for all statistical analyses on the data set. On the student and teacher belief questionnaire, all items are coded corresponding to the numbers on the Likert scale, namely, 5 for strongly agree, 4 for agree, 3 for not sure, 2 for disagree, and 1 for strongly disagree. An independent sample *t*-Test is conducted to evaluate whether there are difference between teachers and students in middle school, with significant level at 0.05(2-tailed). The numbers are also given in percentages.

Table 2. Teachers' and students' beliefs about mathematics

Beliefs about mathematics	Percentage (%)									
	Strongly agree		Agree		Not sure		Disagree		Strongly disagree	
	T	S	T	S	T	S	T	S	T	S
1. Mathematics consists of facts and skills that need to learn by rote	6	43	25	35	19	14	28	8	22	0
2. Mathematics is made of unquestionable Certainty and infallible, there is no need to doubt.	6	37	15	28	13	22	42	7	24	6
3. Mathematics is a valuable and necessary subject.	82	56	13	28	3	16	2	0	0	0
4. Not only mathematician and scientist, but also artist and writer must understand mathematics.	56	49	34	35	8	15	2	1	0	0
5. Concepts and facts of mathematics are absolute and infallible.	2	36	3	38	5	20	48	6	42	0
6. What is the most important in mathematics is instrument for other subjects.	17	59	52	25	18	11	12	3	1	2
7. Mathematics is not only created by itself, but also influenced by human needs.	51	57	36	25	10	16	3	2	0	0
8. Mathematics contains symbols and skills; it is a logically organized system.	24	59	51	20	15	14	10	6	0	1
9. Mathematics cultivates students' reasoning Ability	60	49	34	26	3	17	0	4	3	4
10. Mathematics does not play important in civilization.	0	0	0	0	0	0	6	29	94	71
11. The knowledge of mathematics is learning by rote, it gives few chances for creation.	0	1	0	4	2	3	31	36	67	56
12. Mathematics is human creation and exploration.	41	22	50	36	7	22	0	13	2	7
13. Mathematics is a language.	44	18	47	55	6	14	3	13	0	0

Note. T: teacher ($N=79$), S: student ($N=138$)

RESULT

Beliefs about mathematics

From the Table2, we can see that most teachers opposed to regard mathematics as certainty, infallible, and boring. They were apt to approve that mathematics plays an important role in human civilization, which is closely related to other subjects, and cultivates students' reasoning ability, and they were inclined to think mathematics as an instrument, a language and a logically organized system. And most students are apt to regard mathematics as certainty, infallible, an instrument, a language and a logically organized system. They also approve the values of mathematics on human civilization and the significant relationship with other subjects, and they disapprove it is boring.

Table 3. T-test for beliefs about mathematics

<i>Beliefs about mathematics</i>	<i>Mean</i>		<i>Std. Deviation</i>		<i>p-value</i>
	T	S	T	S	
1.	2.67	4.08	1.24	0.97	.000
2.	2.38	3.83	1.18	1.16	.000
3.	4.75	4.41	0.63	0.75	.000
4.	4.43	4.33	0.74	0.76	.327
5.	1.76	4.05	0.86	0.89	.000
6.	3.70	4.38	0.93	0.90	.000
7.	4.35	4.38	0.76	0.80	.791
8.	3.89	4.30	0.89	1.01	.003
9.	4.48	4.11	0.79	1.11	.002
10.	1.06	1.29	0.24	0.46	.000
11.	1.35	1.56	0.53	0.78	.030
12.	4.25	3.53	0.80	1.19	.000
13.	4.33	3.78	0.71	0.90	.000

Note. T = teacher (N=79), S = student (N=138), $p < .05$ (items were the same as Table 2)

From the table3, we see that the p -values of Q4 and Q7 are higher than .05, and the p -values of Q1, Q2, Q3, Q5, Q6, Q8, Q9, Q10, Q11, Q12, and Q13 are lower than 0.05. It means that both teachers and students are apt to think mathematics is closely related to other subjects and human life. And there are differences between teachers' beliefs and students' beliefs.

The most of teachers are apt to feel that mathematics is a language, a valuable and necessary subject, a human creation, explorations. Mathematics can cultivate students'

reasoning ability.

Table 4. Teachers' and students' beliefs about mathematics learning

Beliefs about mathematics learning	Percentage									
	Strongly Agree		Agree		Not Sure		Disagree		Strongly Disagree	
	T	S	T	S	T	S	T	S	T	S
1 Teachers should explain the relationship between new contents and the former, which is most important in mathematics learning.	9	59	21	25	27	11	33	3	10	2
2 Mathematics problems can be solved in different ways.	27	56	48	28	22	15	3	1	0	0
3 Mathematics problems must be solved in ten minutes.	0	0	2	0	9	0	34	29	55	71
4 What is most important in mathematics is its application.	21	22	44	36	27	22	8	13	0	7
5 Individual study is more important than group learning.	3	1	8	4	15	3	66	36	8	56
6 It is important for the students to challenge the new problems.	27	43	52	35	15	14	6	8	0	0
7 Students must learn the content on the textbook or notebook by rote.	2	2	0	14	0	12	22	14	76	58
8 Students should learn the facts, formulas and theorems by rote, if they want to learn mathematics well.	3	1	2	3	3	4	31	56	61	36
9 Cultivating students' creating thinking ability is the key factor in learning mathematic	24	59	32	25	39	11	5	2	0	3
10 It is a waste time of time to solve a problem in a long time.	3	36	5	38	6	20	44	6	42	0
11 Students shouldn't content with learning skills, they needs to understand the logic in math.	30	64	55	2	12	16	3	0	0	0
12 In learning mathematics, students should understand the truth and conceptions.	27	59	45	11	16	25	12	3	0	2
13 Students can't solve problems if they don't memory the theorems and formulas.	5	22	8	22	25	22	40	22	22	12
14 Students must learn basic facts and skills before problem-solving.	19	59	50	20	19	14	12	6	0	1
15 Students must follow the teachers way of solve problems, and do similar exercises.	2	7	12	14	38	6	37	22	11	51
16 Learning mathematics requires talent.	9	60	30	20	35	14	21	6	5	0

Note. T: teacher ($N=79$), S: student ($N=138$)

They are more inclined to think that mathematics is not unquestionable certainty and infallible, and it is not absolute.

Comparing with teachers, most students are apt to feel that mathematics consists of facts and skills, and it is unquestionable, absolute and infallible. They are more inclined to believe mathematics is an instrument and a logically organized system than teachers.

Table 5. *t*-Test for beliefs about mathematics learning

Beliefs about mathematics learning	Mean		Std. Deviation		<i>p</i> -value
	T	S	T	S	
1.	2.86	4.38	1.13	0.90	0.000
2.	3.98	4.40	0.77	0.77	0.000
3.	1.59	1.29	0.76	0.46	0.002
4.	3.79	3.54	0.86	1.16	0.061
5.	2.34	1.55	0.87	0.78	0.000
6.	3.98	4.14	0.82	0.92	0.164
7.	1.32	1.87	0.72	1.18	0.000
8.	1.56	1.75	0.88	0.72	0.059
9.	3.75	4.37	0.88	0.94	0.000
10.	1.82	4.05	0.94	0.89	0.000
11.	4.11	4.48	0.75	0.76	0.001
12.	3.87	4.22	0.93	1.04	0.013
13.	2.34	3.17	1.05	1.34	0.000
14.	3.77	4.31	0.89	0.97	0.000
15.	2.57	2.04	0.92	1.33	0.001
16.	3.18	4.34	1.02	0.92	0.000

Note. T: teacher ($N=79$), S: student ($N=138$), $p < 0.05$ (items were the same as Table 4)

Beliefs about mathematics learning

From the table 4, we get that most teachers believe that mathematics problem can be solved in different ways, and needn't to be solved in ten minutes, it is not wasting time to solve a problem in a long time. And most students think that they can solve mathematics problems if they do not memory the theorems and formulas, but must learn basic facts and skills before. Most teachers think that the aims of mathematics learning are cultivating students' creative thinking ability and to learn application of the mathematics knowledge, and comprehension and challenging are very important ways of learning mathematics.

They oppose rote learning. Most students believe that mathematics problems can be solved in different ways, and needn't be solved in ten minutes, and it is wasting time to solve a problem in a long time. They also think that the aims of mathematics learning is cultivating students' creative thinking ability, and to learn application of the mathematics knowledge. Mathematics learning is not following the teachers' way of solving problem, learning by rote, and doing a lot of exercises, but challenging and comprehension. Students emphasize that learning mathematics requires talent.

From the table5, we get that the p-values of Q1, Q2, Q3, Q5, Q7, Q9, Q10, Q11, Q12, Q13, Q14, Q15, and Q16 are lower than .05, and the p-values of Q4, Q6, and Q8 are higher than .05. So, we know that both teachers and students are believe that what is the most important in mathematics is its application, and challenging is very important in mathematic learning, and both teachers and students oppose learning facts, formulas and theorems by rote. And there are the differences between teachers' and students' views:

Most teachers are apt to feel that learning the content on the textbook or Notebook by rote is not a good way. They believe that solving problems in a long time is not waste of time, and students also can solve problems if they don't remember the theorems and formulas.

Comparing with teachers, most students are apt to believe that there are different ways to solve problems, and it's wasting time to solve a problem in a long time. Students are more inclined to believe that group learning is more important than individual study, they must learn basic facts and skills before problem-solving, the aim of learning mathematics is cultivating students' creative thinking ability, the good ways to learn mathematics are not individual learning, but following teachers and doing lots of exercises. And Students emphasize learning mathematics requires talent.

Beliefs about mathematics teaching

The percentage of teachers' and students' beliefs about mathematics teaching is showed in Table 6. Most teachers believe that the nature of mathematics teaching is a process that students experience mathematization, and a process of students own construction. The purpose of mathematics teaching is to help students understand the conceptions, acquire the skills, solve the problems, and learn creation. The good way to teach mathematics is emphasizing the textbook, airing students' own opinion, solving one problem in different ways, leading students to think and explore, and paying attention to students' process of learning. They oppose the teacher must know the answer about the question which the students asked.

Table 6. Beliefs about mathematics teaching of teachers and students

Beliefs about mathematics teaching	Percentage (%)									
	Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree	
	T	S	T	S	T	S	T	S	T	S
1. It is necessary to understand the conceptions and acquire the skills in the process of teaching.	24	59	45	20	27	14	2	6	2	1
2. If a student asks a question in math, the teacher should know the answer.	20	58	26	22	23	14	28	6	3	0
3. In order to improve the instruction, teachers should pay more attention to the textbook.	62	93	30	7	5	0	3	0	0	0
4. The purpose of teaching is to help the students think mathematically and learn to solve problems.	28	59	37	11	18	25	15	3	2	2
5. Teachers task is to teach the student in a rigorous and logic way.	9	58	17	22	27	20	42	0	5	0
6. The teaching of mathematics should include students' thinking and exploration.	38	63	48	21	8	16	6	0	0	0
7. Only the teacher knows whether the students' answers are correct or not.	0	65	0	14	2	21	36	0	62	0
8. Students learn creation in studying mathematics.	28	58	45	16	16	14	9	12	2	0
9. Teachers should put emphasis on the process of problem-solving.	15	40	43	20	22	20	18	20	2	0
10. Teachers should encourage students to come up with their own statement.	53	69	39	11	8	14	0	6	0	0
11. It is very productive for students to work math activities and solve the problems in different ways.	28	60	42	24	28	16	2	0	0	0
12. Mathematics learning is a process that students experience mathematization.	27	36	49	23	16	28	6	13	2	0
13. Teachers should assess the students with open-ended questions, which answer is uncertain	9	7	27	14	28	6	30	22	6	51
14. The process of learning should be a major consideration when it evaluates the students learning.	35	36	52	20	5	24	6	20	2	0
15. Mathematics teaching is a process of students own construction.	24	30	33	32	22	18	18	13	3	7

Note. T: teacher ($N=79$), S: student ($N=138$)

Most students believe that the nature of mathematics teaching is a process of their construction and mathematization, and the purpose of mathematics teaching is to help students understand the conceptions, acquire the skills, and solve problems, and learn creation. They think the good way to teach mathematics is that a teacher must pay more attention to the textbook, air their own opinion, solve one problem in different ways, teach them in a rigorous and logic way, lead them to think and explore, and pay attention to their process of learning. Most students think that the teacher should know the answer about the questions which they asked, and only the teacher can give them the right answer. They oppose open-ended problems.

Table 7. *t*-Test for beliefs about mathematics teaching

Beliefs about mathematics teaching	Mean		Std. Deviation		P-value
	T	S	T	S	
1	3.89	4.29	0.85	1.01	.001
2	3.34	4.33	1.16	.92	.000
3	4.52	4.93	0.71	.26	.000
4	3.72	4.24	1.10	1.02	.001
5	2.82	4.38	1.05	.80	.000
6	3.99	4.48	0.82	.76	.007
7	1.32	4.44	0.73	.81	.000
8	3.86	4.20	1.00	1.09	.023
9	3.51	3.78	1.04	1.17	.073
10	4.46	4.43	0.64	.94	.794
11	3.95	4.44	0.81	.75	.000
12	3.91	3.83	0.95	1.07	.544
13	3.01	2.04	1.09	1.34	.000
14	4.09	3.71	0.94	1.15	.009
15	3.58	3.64	1.12	1.24	.743

Note. T: teacher (N=79), S: student (N=138), $p < .05$ (items were the same as table 6)

From Table 7, we get that the p -values of Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q11, Q13, and Q14 obtained from t tests are lower than 0.05, which means that there are significant differences between teachers' and students' views about these items. The p -values of Q9, Q10, Q12, and Q15 are higher than 0.05; it means that there are no significant differences about the items.

From above, we know that teachers and students are both apt to emphasize the progress of problem solving, the nature of mathematics teaching is the process of students' construction and mathematization, and mathematics teaching must air students' own

opinion. We also get the differences between teachers' and students' views.

Most teachers are less apt to emphasize that the purpose of mathematics teaching is to help students understand the conceptions, acquire the skills, solve problems, and learn creation. They are inclined to emphasize the good way to teach mathematics is paying more attention to students' process of learning. They oppose that only teacher knows whether the students' answers are correct or not.

Comparing with teachers, most students are more apt to feel the purpose of mathematics teaching is to help students understand conceptions, acquire the skills, solve problems, and learn creation. They are more inclined to emphasize that the good way to teach mathematics is emphasizing the textbook and solving one problem in different ways, teaching them in a rigorous and logic way and leading them to think and explore, and oppose open-ended problems. They also believe that the teacher should know the answer, and only the teacher can give them the right answer.

CONCLUSION AND DISCUSSION

In conclusion, there are some differences between Chinese mathematics teachers' and their students' beliefs about mathematics, mathematics teaching and learning.

Beliefs about mathematics

First, their views about the nature of mathematics are different. Most students are apt to think mathematics as certainty, infallible, and an instrument. But most teachers are more inclined to consider mathematics as a language.

Second, their views about the values of mathematics are different. Most teachers are more inclined to emphasis the values of mathematics on human civilization than students.

Beliefs about mathematics learning

First, their views about problem solving are different. Most students are more inclined to believe that there are different ways for solving a problem, and it's wasting time to solve a problem in a long time, and more oppose that solving problems must be in ten minutes. But most teachers believe that students must learn basic facts and skills before solving problems, and they also emphasize that it is not key to solve problems whether they remember the theorems and formulas or not.

Second, their views about the aim of learning mathematics are different. Most teachers are more inclined to oppose that the aim of learning mathematics is learning the content on the textbook or notebook by rote. But students are more inclined to emphasize that the

aim of learning mathematics is culturing students' creative thinking ability.

Third, their views about the ways of learning mathematics are different. Most students are more inclined to emphasize that comprehension is a good way to learn mathematics, and group learning is more important than individual learning. Most teachers believe following teachers and doing lots of exercises are good ways to learning mathematics.

Forth, their views about the ability of learning mathematics are different. Students emphasize learning mathematics requires talent, but teachers don't.

Beliefs about mathematics teaching

First, their views about the purpose of learning mathematics are different.

Most students are more apt to feel the purpose of mathematics teaching is to help students understand the conceptions, acquire the skills, solve problems, and learn creation.

Second, their views about the ways of learning mathematics are different.

Most students are more apt to emphasize the good ways to teach mathematics are emphasizing the textbook and solving a problem in different ways, teaching them in a rigorous and logic way, and leading students to think and explore. But teachers pay more attention to students' process of learning. Students oppose the problems of the exams should be open-ended problems but teachers didn't.

Third, their views about the role of teachers are different. Most students believe that the teacher should know the answer, and only the teacher can give them the right answer, but teachers did not.

Discussion

From the differences between Chinese mathematics teachers' beliefs and their students' beliefs, we can get that the students' beliefs are not the same as the teachers' and the teachers' beliefs are more positive than students'. The reasons maybe:

First, beliefs can not be taught as knowledge. Knowledge is specific. Teachers can tell students what the specific knowledge is by teaching. But they can not indoctrinate students with their beliefs. Belief is not directly from outside by infusing (Li, 2001). Students' beliefs only can be imperceptibly influenced by the process of teaching.

Second, belief is subjective. Belief is a part of affection domain. Students' beliefs are rooted in their practical experience and cognitive process in which they have realized something; after a period of time, these things which they have realized form beliefs.

Third, teachers' beliefs are not all diverted to students very well in the process of teaching. Teachers' beliefs play a significant role in the formation process of students' beliefs. Students participate in most activities of teaching and learning with teachers together. So, we can change students' beliefs to be positive by teachers.

There are some recommendations as follows:

- (1) Teachers must ensure that they hold positive beliefs.
- (2) Teachers should express their beliefs through teaching. Teachers should avoid expressing negative affection when they face the students.
- (3) Teachers should concern about students' beliefs. Keeping up concerning about students' beliefs is a good way to get the feedback of teaching. According to students' beliefs teachers can restructure the instruction effectively, and improve the effect of teaching.

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APPENDIX A

SUBTYPES OF BELIEFS

Subtypes	Items	Examples of the questionnaire
Beliefs about mathematics	Nature of mathematics	Mathematics consists of facts and skills that need to learn by rote.
	Relationships between mathematics and other subjects and life	Not only mathematician and scientist, but also artist and writer must understand mathematics.
	Value of mathematics	Mathematics is a valuable and necessary subject.
Beliefs about mathematics learning	Mathematics problems solving	Mathematics problems can be solved in different ways.
	Aims of learning mathematics	What is most important in mathematics is its application.
	Ways of learning mathematics	In learning mathematics, students should understand the Conceptions and truth.
	Ability of mathematics	Learning mathematics requires talent.
Beliefs about mathematics teaching	Nature of teaching mathematics	Mathematics teaching is a process that students own construction.
	Purpose of teaching mathematics	The purpose of teaching is to help the students think mathematically and learn to solve problems.
	Ways of teaching mathematics	Teacher's task is to teach the student in a rigorous and logic way.
	Role of teacher	Only the teacher knows whether the students answer is correct or not.