



Research on the Cognitive Degree of Pre-service Mathematics Teachers for Mathematical Reasoning Ability in Junior High School in China

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Currently, the education of junior high school mathematical reasoning ability has been widely concerned by all walks of life. Many relevant problems about it have been studied except the cognitive degree of pre-service mathematics teachers for the mathematical reasoning ability in junior high school. To address this problem, this study investigates 25 pre-service mathematics teachers' cognitive degree of junior high school mathematical reasoning ability through open-ended interviews, obtains the current situation of pre-service teachers' cognitive degree of mathematical reasoning ability in junior high school, and gives targeted suggestions for training pre-service mathematics teachers, so as to promote the implementation of the training goal of mathematical reasoning ability in junior high school. After analyzing, it can be found that: (1) The cognitive scope of the current pre-service mathematics teachers' mathematical reasoning ability is not wide, more than half of the people do not recognize half of the content; (2) The cognition of many pre-service teachers is not deep, and their understanding of ability performances is simple; (3) The cognition of

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many pre-service teachers for many aspects of mathematical reasoning ability is not clear. Therefore, it is suggested that: (1) Experts and teachers who are responsible for educating teachers should pay more attention to mathematical reasoning ability in junior high school and add relevant courses; (2) Pre-service mathematics teachers should understand the content of junior high school mathematical reasoning ability comprehensively and deeply, and clarify relevant statements.

Keywords: Pre-Service teachers; junior high school; mathematical reasoning ability; cognitive degree.

1. INTRODUCTION

“The national curriculum standard is an important program document for the reform and implementation of the national curriculum, and its promulgation, revision, and application have a very important impact on the mathematics education of primary and secondary schools in a country. *The Compulsory Education Mathematics Curriculum Standards (2022 Edition)* (hereinafter referred to as the *Curriculum Standards (2022 Edition)*) promulgated by the Ministry of Education of the People’s Republic of China in 2022 details the requirements for the development of students’ mathematics core literacy and clarifies the correct values, essential qualities and key abilities that the curriculum should focus on cultivating. In addition, the Ministry of Education of the People’s Republic of China has pointed out that it should systematically promote the implementation of the *Curriculum Standards (2022 Edition)*. Mathematical reasoning ability is an essential ability for students to learn mathematics, cultivating students’ mathematical reasoning ability has always been among the goals of mathematics compulsory education in China” [1]. The latest *Curriculum Standards (2022 Edition)* takes mathematical reasoning ability as one of the main manifestations of mathematics core literacy in junior high school and clearly gives its meaning, that is, the ability that starts from some facts and propositions and other propositions or conclusions are deduced according to the rules, and points out that this ability helps students develop a habit of thinking that emphasizes arguments and logic, and form a scientific attitude and rational spirit of seeking truth from facts [2]. Therefore, the education on the implementation of mathematical reasoning ability in junior high school has been widely concerned by all walks of life. However, after extensive discussion and research by many scholars and teachers on the current situation of junior high school students’ mathematical reasoning ability, it is found that the current level of junior high school students’ mathematical reasoning ability

is not high, and the cultivation of mathematical reasoning ability has not been well implemented in practical teaching [3]. What are the reasons for this? How to cultivate the mathematical reasoning ability of junior high school students? These questions are worth studying. Therefore, it is necessary to sort out the relevant research on the implementation of mathematical reasoning ability in junior high school mathematics teaching through a literature review, carry out the investigation to get the current situation, and give targeted suggestions to promote the implementation of the training goal of junior high school mathematical reasoning ability.

2. LITERATURE REVIEW

Currently, there have been several studies on this issue of implementing mathematical reasoning ability in junior high school mathematics teaching.

2.1 The Situation of Junior High School Students’ Mathematical Reasoning Ability Level

“Before the promulgation of the *Curriculum Standards (2022 Edition)*, Zhou pointed out that the mathematical reasoning ability of junior high school students was at a medium level based on the results of the 2016 academic quality monitoring in Jiangsu Province, and there was a problem of low level of plausible reasoning” [4]. In 2020, Wang SL tested the students and found that the overall level of mathematical reasoning ability of junior high school students was at a medium level, their ability to find mathematical problems in related situations was weak, and their ability to understand mathematical propositions and solve complex problems in related mathematical propositions was weak [5]. According to Wang SN, she found that the level of junior high school students’ mathematical reasoning ability was above average, and there was no significant difference between genders, but there were significant differences between schools, students in key junior high schools had stronger mathematical reasoning ability than

those in ordinary junior high schools. In addition, she pointed out that the development of junior high school mathematical reasoning ability depends on the mastery of reasoning rules and the understanding of mathematical knowledge [6].

After the promulgation of the *Curriculum Standards (2022 Edition)*, Xiong tested grade 8 students and found similar research results to Wang SN, who pointed out that students had problems of over-reliance on intuitive thinking and weak logical reasoning completeness [6,7]. Liu found that students' level of mathematical reasoning ability was mainly at a medium level, and there was a problem of not thinking rigorously [3].

It can be seen that before and after the promulgation of the *Curriculum Standards (2022 Edition)*, the level of mathematical reasoning ability of junior high school students is generally at a medium level. Many problems in junior high school mathematics teaching have not been solved, and the level of students' mathematical reasoning ability has not been improved.

2.2 The Factors Affecting Students' Mathematical Reasoning Ability

Through data analysis and interviews, Wang SL concluded that junior high school students' mathematics learning strategies, cognitive structure, teachers' teaching strategies, and learning motivation had a direct positive impact on their mathematical reasoning ability, and the effect decreased in turn [5]. Through interviews, Lan concluded that the direct factors affecting the mathematical reasoning ability of grade 8 students included mathematical reading, knowledge base, thinking mode, level requirements, other core mathematical literacy and ability, and reflection level. The indirect factors included the psychological process of individual students (cognitive process, emotional process, will process), personality psychology (ability, interest, personality, habits, etc.), teaching resources, and classroom atmosphere of schools and classes [8]. Yan found that the logical reasoning ability of junior high school students is limited by the mastery of mathematical knowledge and the mastery of logical forms through the test [1]. Han obtained the influencing factors of junior high school students' mathematical inductive reasoning ability through questionnaires and interviews, including two aspects of teachers and students. Teachers' factors included the understanding of the importance of inductive reasoning, the

degree of mining of teaching materials, and teaching methods. Students' factors included interest in mathematics learning, cognition of mathematical inductive reasoning, mathematics learning habits, and mathematical thinking in the process of reasoning [9].

Therefore, it can be seen that the current influencing factors on junior high school students' mathematical reasoning ability are mainly concentrated in two aspects: teachers and students. Students' mathematical cognitive structure, learning strategies, personality psychology, teachers' cognition of the importance of mathematical reasoning ability, and teaching strategies all impact junior high school students' mathematical reasoning ability.

2.3 Strategies for Developing Junior High School Students' Mathematical Reasoning Ability

According to Wang XF, he pointed out that mathematical experiments could provide students with rich problem situations for their mathematical learning so that students could experience the complete reasoning process of plausible reasoning to find conclusions and deductive reasoning to prove conclusions. It was an important learning method to cultivate students' mathematical reasoning ability [10]. Lan stressed that schools need to strengthen the training of teachers and explore new teaching resources; teachers should improve students' reflective ability [8]. Wang Y pointed out through theoretical speculation that when students learn new concepts, teachers should explain the reasoning process of concepts to students, such as practicing deducing new concepts with the old knowledge learned and establishing connections between new and old concepts [11]. Han believed that teachers themselves should: (1) Improve their mathematical literacy; (2) Explore the content of teaching materials, deepen the understanding of inductive reasoning, and consciously infiltrate inductive reasoning into the classroom; (3) Pay attention to the creation of problem situations and cultivate students' mathematical inductive reasoning ability in situational teaching. She also believed that in terms of students, teachers should: (1) Deepen students' understanding of inductive reasoning and standardize the problem-solving process; (2) Establish students' confidence in learning and improve their interest in learning mathematics in the learning process; (3) Cultivate students' good learning habits in the learning process [9]. Yao

combined with the actual teaching experience in the classroom, came to the same conclusion as Han [12]. Gu pointed out that teachers should strengthen the development of teaching resources under the background of information technology and optimize the process and evaluation of mathematics teaching [13]. Xiong pointed out that teachers need to combine the students' cognitive development rule, stimulate students' interest, and guide students to learn to think independently and from multiple perspectives [7].

It can be seen that the strategies proposed by scholars mainly include strengthening teachers' cognition of mathematical reasoning ability, creating problem situations, and developing teaching resources. These strategies need to be implemented by teachers, who play an important role in the cultivation of junior high school students' mathematical reasoning ability.

From the above studies, it can be seen that many scholars have studied mathematical reasoning ability in terms of its situation, influencing factors, and cultivation strategies. However, few people have studied teachers' mathematical reasoning ability, and the research on teachers' cognitive degree of mathematical reasoning ability in junior high school is in a gap. The improvement of students' mathematical reasoning ability is mainly realized in classroom teaching, and teachers play a key role in cultivating students' mathematical reasoning ability. Only when teachers' cognition of mathematical reasoning ability is scientific, can the implementation of their teaching behavior achieve better teaching results [14]. Pre-service mathematics teachers as an important resource, their professional development and research is one of the hot problems in the study of current mathematics education. At present, there have been many studies on pre-service mathematics teachers. For example, Kusuma studied the algebraic thinking of pre-service mathematics teachers based on systematic-intuitive cognitive style, and explored the relationship between algebraic thinking ability and cognitive style [15]. Therefore, this study aims to investigate the current pre-service mathematics teachers' cognitive degree of mathematical reasoning ability in junior high school. The cognitive degree generally includes cognitive breadth, cognitive depth, and cognitive clarity. Therefore, the main issues of this study are:

1. How wide is pre-service mathematics teachers' cognitive degree of junior high

school mathematical reasoning ability?

2. How deep is pre-service mathematics teachers' cognitive degree of junior high school mathematical reasoning ability?
3. Is the current pre-service mathematics teachers' cognition of junior high school mathematical reasoning ability clear?

At present, several studies have shown that the level of mathematical reasoning ability of junior high school students is not high, and teachers' cognition of mathematical reasoning ability is an important factor affecting students' mathematical reasoning ability. Therefore, the hypotheses of this study are:

Hypothesis 1: The current pre-service mathematics teachers' cognitive degree of junior high school mathematical reasoning ability is not wide;

Hypothesis 2: The current pre-service mathematics teachers' cognitive degree of junior high school mathematical reasoning ability is not deep;

Hypothesis 3: The current pre-service mathematics teachers' cognitive degree of junior high school mathematical reasoning ability is not clear.

3. THEORETICAL BASIS

There have been many previous studies on mathematical reasoning ability and its main components.

"The famous mathematician Polya points out that mathematical reasoning includes proof reasoning and plausible reasoning in his book *Mathematics and Conjecture*" [16]. "In 2011, the Ministry of Education of the People's Republic of China promulgated the *Compulsory Education Mathematics Curriculum Standards (2011 Edition)*, which points out that the development of reasoning ability should run through the whole process of mathematics learning. Reasoning is the basic way of thinking in mathematics, and it is also a common way of thinking in people's learning and life. Reasoning generally includes plausible reasoning and deductive reasoning. Plausible reasoning is based on the existing facts, relying on experience and intuition, through induction and analogy to infer some results; deductive reasoning starts from the existing facts (including definitions, axioms, theorems, etc.) and certain rules (including the definition, rules, order, etc.), and proves and calculates according

to the rules of logical reasoning” [17]. Subsequently, more and more scholars and experts have studied the connotation and structure of mathematical reasoning ability. Wu believes that reasoning ability is the synthesis of relatively stable individual psychological characteristics formed, embodied, and developed in reasoning activities, which affects the effect of reasoning activities. Through theoretical speculation, he analyzes the structural elements of reasoning ability from the perspective of the five requirements of reasoning effectiveness, clarity and orderliness, flexibility, creativity, and introspection in the problem-solving process [18]. Cao believes that the essential function of reasoning is to draw conclusions and generate new knowledge [19]. “*The Curriculum Standards for General High School Mathematics (2017 Edition)* points out that the core literacy of mathematics is a comprehensive embodiment of the thinking quality, key ability, emotion, attitude, and values with the basic characteristics of mathematics, and lists logical reasoning as one of the core literacy of mathematics. It also points out that logical reasoning refers to the literacy that it starts from some facts and propositions and other propositions are deduced according to the rules, including reasoning from special to general and reasoning from general to special. The former’s reasoning forms mainly include induction and analogy, and the latter’s reasoning forms mainly include deduction” [20].

The Ministry of Education of the People’s Republic of China has comprehensively summarized the above viewpoints. *Curriculum Standards (2022 Edition)*, the latest edition, points out that students should form and develop the core literacy needed for social and personal development through mathematics learning, and the main manifestations of core literacy are accurately defined. Among them, mathematical reasoning ability is one of the main manifestations of core literacy in junior high school. Its meaning refers to the ability that it starts from some facts and propositions and other propositions or conclusions are deduced according to the rules [2]. Furthermore, *Curriculum Standards (2022 Edition)* makes a very clear statement on the performances of mathematical reasoning ability, including two aspects: key ability performances and character and value performances. The key ability performances include understanding the importance of logical reasoning in the formation of mathematical concepts, rules, theorems, and

problem-solving, and mastering the basic forms and rules of reasoning. For some simple problems, general conclusions can be inferred from special results. To understand the structure and connection of propositions, explore and express the process of demonstration. To understand the rigor of mathematics and form the habit of logical expression and communication. Character and values performances include gradually developing a habit of thinking that emphasizes arguments and logic, forming a scientific attitude, and a rational spirit of seeking truth from facts [2,21].

Therefore, this study adopts the definition of mathematical reasoning ability by *Curriculum Standards (2022 Edition)* to research the cognitive degree of pre-service mathematics teachers for mathematical reasoning ability in junior high school from three aspects: the meaning of mathematical reasoning ability, the key ability performances, and the character and value performances.

4. METHODS

4.1 Participants

In this study, 10 undergraduate graduates and 15 master of education graduates from the School of Mathematics and Statistics of Shandong Normal University in China were selected as the survey objects. They all hold mathematics teacher qualification certificates and have the intention to go to junior high school teaching. Taking them as the survey objects can truly reflect the current pre-service mathematics teachers’ cognitive degree of junior high school mathematical reasoning ability.

4.2 Instrument

In this study, the open-ended interview method is used to investigate, and the interview outline is designed with three questions, “How do you understand mathematical reasoning ability in junior high school? What are the key ability performances of mathematical reasoning ability? What are the character and value performances of mathematical reasoning ability?”. Then invite the survey objects to say their understanding of these three issues in detail and comprehensively. The open-ended interview method is adopted because it is fast, convenient, flexible, and not restricted by written language, and it facilitates in-depth investigations to obtain the most direct information.

Table 1. Content coding

Category	Label	Content
A Meaning	A1	Starts from some facts and propositions
	A2	According to the rules
	A3	Deduce other propositions or conclusions
B Key Ability Performances	B1	Understand the importance of logical reasoning in the formation of mathematical concepts, rules, theorems, and problem-solving
	B2	Master the basic forms and rules of reasoning
	B3	General conclusions can be inferred from special results
	B4	Understand the structure and connection of propositions
	B5	Explore and express the process of demonstration
	B6	Understand the rigor of mathematics
	B7	Form the habit of logical expression and communication
C Character and Value Performances	C1	Develop a habit of thinking that emphasizes arguments and logic
	C2	Form a scientific attitude and rational spirit of seeking truth from facts

4.3 Data Collection

To ensure the reliability of the research, this study uses an open-ended interview method to interview 25 pre-service mathematics teachers one by one individually. In addition, the whole interview content is recorded during the whole process after the consent of the survey object is sought.

4.4 Data Processing

Firstly, divide and code the content related to the junior high school mathematical reasoning ability in the Curriculum Standards (2022 Edition). A, B, and C are used to represent the meaning, key ability performances, character and value performances of mathematical reasoning ability, and the content of each aspect is represented by numbers. A total of 12 items of A1-C2 are divided. The specific coding and its meaning are shown in Table 1.

Subsequently, the survey objects are coded, with 15 graduates of Master of Education corresponding to codes a1 to a15, and 10 graduates of undergraduate corresponding to codes b1 to b10. Then convert the interview recording content into text form and compare it with the encoded content one by one. If the content meaning is similar, the survey object is considered to be able to recognize this item. In addition, cognitive clarity is judged based on the completeness and accuracy of the survey objects' expressions. Finally, count the number of items recognized by each survey object and the number of people mentioned in each item, calculate the corresponding percentage, and make a statistical table.

5. RESULTS

5.1 Cognitive Breadth

In the Curriculum Standards (2022 Edition), the content of junior high school mathematical reasoning ability is divided into 12 items. From the perspective of the number of personal cognitive items, the survey objects recognize at most 11 items and at least 1 item. Among them, only 11 people recognize 6 or more items, and the other 14 people recognize only 2 items. The details are shown in Fig. 1.

From the number of people mentioned in each item, all survey objects can recognize 11 items to the greatest extent. The meaning is divided into 3 items, and survey objects can recognize 3 items to the greatest extent. The key ability performances are divided into 7 items, and survey objects can recognize 6 items to the greatest extent. Character and value performances are divided into 2 items, and survey objects can recognize two items to the greatest extent. However, there is a large gap in the number of people recognized for each item. The number of people who recognize that mathematical reasoning ability should be based on rules is the largest, with 15 people, accounting for 60%. The number of people who have recognized the three items of "understand the structure and connection of propositions", "form the habit of logical expression and communication", and "understand the rigor of mathematics" is small. There are 0, 4, and 5 people, respectively, accounting for 0%, 16%, and 20%.

Therefore, it can be seen that the current pre-service mathematics teachers do not have a wide range of cognition about mathematical reasoning ability, and more than half of them do not recognize half of the content of mathematical reasoning ability. In terms of specific content, the cognitive degree of the stronger generality of mathematical reasoning ability is higher, such as its meaning, while the cognitive degree of key ability performances in junior high school is lower. The details are shown in Table 2.

5.2 Cognitive Depth

From Table 2, it can be seen that survey objects have a deeper understanding of the three items of the meaning of mathematical reasoning ability, and the number of people who recognize each item is more than half of the total number. Among the seven items of the key ability performances of mathematical reasoning ability, survey objects have a deeper understanding of the three items of “master the basic forms and rules of reasoning”, “general conclusions can be inferred from special results”, and “explore and express the process of demonstration”, while the cognitive depth of the four items of “understand the importance of logical reasoning in the formation of mathematical concepts, rules, theorems and problem-solving”, “understand the rigor of mathematics”, “form the habit of logical expression and communication”, “understand the

structure and connection of propositions” is gradually reduced, the number of people who recognized accounted for 40%, 20%, 16% and 0% of the total number, respectively. In terms of the character and value performances of mathematical reasoning ability, 56 % of the survey objects recognized the item “develop a habit of thinking that emphasizes arguments and logic”, and only 6 people recognized the content of “form a scientific attitude and a rational spirit of seeking truth from facts”.

Therefore, it can be seen that the current pre-service mathematics teachers have a deep and comprehensive understanding of the meaning of mathematical reasoning ability, while the two aspects of junior high school mathematical reasoning ability are relatively simple and incomplete. On the whole, the pre-service mathematics teachers’ cognition of mathematical reasoning ability in junior high school is relatively shallow and not deep enough.

5.3 Cognitive Clarity

In this study, according to the completeness and accuracy of the survey objects’ expressions, cognitive clarity is judged. Then, the percentage of people with high and low clarity in the number of people who recognize each item is calculated respectively, as well as the percentage of people with high cognitive clarity in the total number of people. The details are shown in Table 3.

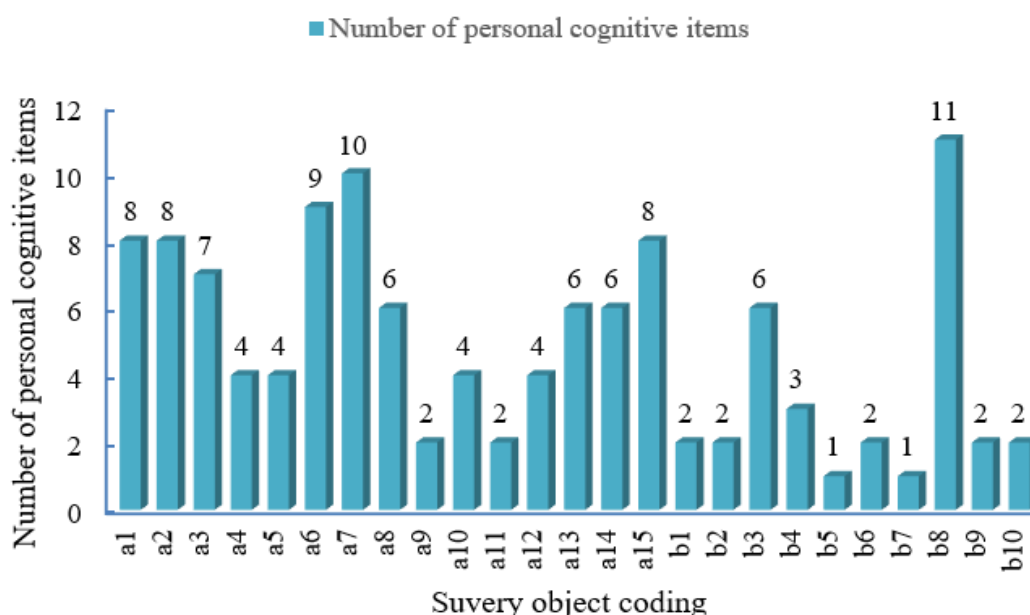


Fig. 1. Number of personal cognitive items of survey objects

Table 2. Statistics of cognitive breadth and depth results

Category	Label	Number	Percentagez	Cognitive points	Total points	Percentage
A Meaning	A1	14	56%	3	3	100%
	A2	15	60%			
	A3	13	52%			
B Key Ability Performances	B1	10	40%	6	7	85.71%
	B2	13	52%			
	B3	14	56%			
	B4	0	0%			
	B5	12	48%			
	B6	5	20%			
	B7	4	16%			
C Character and Value Performances	C1	14	56%	2	2	100%
	C2	6	24%			

Table 3. Statistics of cognitive clarity results

Category	Label	Number of people recognized	Number of people with clear cognition	Percentage of cognitive clarity(high degree: low degree)	Percentage
A Meaning	A1	14	2	14.29%:85.71%	8%
	A2	15	7	46.67%:53.33%	28%
	A3	13	3	23.08%:76.92%	12%
B Key Ability Performances	B1	10	2	20.00%:80.00%	8%
	B2	13	7	53.85%:46.15%	28%
	B3	14	3	21.43%:78.57%	12%
	B4	0	0	0.00%:100.00%	0%
	B5	12	4	33.33%:66.67%	16%
	B6	5	4	80.00%:20.00%	16%
	B7	4	1	25.00%:75.00%	4%
C Character and Value Performances	C1	14	6	42.86%:57.14%	24%
	C2	6	1	16.67%:83.33%	4%

From Table 3, it can be seen that the clearest cognition of survey objects is the two items of “according to the rules” in the meaning and “master the basic forms and rules of reasoning” in the performances, accounting for 28% of the total number. The survey objects had the lowest cognitive clarity on “understand the structure and connection of propositions”, “form the habit of logical expression and communication”, and “form a scientific attitude and rational spirit of seeking truth from facts”, accounting for 0%, 4% and 4% of the total number, respectively.

From the perspective of the clarity of the survey objects recognized by each item, there is no 100 % clarity in the 12 items. Most people only know these items but lack completeness and accuracy in their expression.

Therefore, it can be seen that the current pre-service mathematics teachers’ cognitive clarity is low, and their expression of mathematical reasoning ability is vague.

6. DISCUSSION

6.1 Cognitive Breadth

According to the above data analysis, it can be seen that the current pre-service mathematics teachers do not have a wide range of cognition about junior high school mathematical reasoning ability, and more than half of them do not recognize half of the content. In terms of specific content, the cognitive degree of the stronger generality of mathematical reasoning ability is higher, such as its meaning, while the cognitive degree of key ability performances is lower. From

this, we can see that the current pre-service mathematics teachers do not have a wide range of cognition of junior high school mathematical reasoning ability. The reason may be that pre-service mathematics teachers have learned the contents of *The Curriculum Standards for General High School Mathematics (2017 Edition)* in the classroom, they are familiar with the content of mathematical core literacy, so they are familiar with the meaning of mathematical reasoning ability. They have not studied *Curriculum Standards (2022 Edition)*, so they do not understand the content of performances of mathematical reasoning ability in the latest curriculum standards. Regarding this question, when studying the influencing factors of junior high school students' mathematical reasoning ability, Jia finds that some mathematics teachers are not clear about the meaning and classification of mathematical reasoning ability, teachers' understanding of mathematical reasoning ability is not in place [22]. Thus hypothesis 1 is confirmed.

6.2 Cognitive Depth

According to the above data analysis, it can be seen that the current pre-service mathematics teachers have a deep and comprehensive understanding of the meaning of mathematical reasoning ability, while the two aspects of mathematical reasoning ability are relatively simple and incomplete. On the whole, the pre-service mathematics teachers' cognition of junior high school mathematical reasoning ability is relatively shallow and not deep enough. From this, we can see that the current pre-service mathematics teachers' cognition is not deep. The reason may be that pre-service mathematics teachers do not pay enough attention to the current education reform, so they do not know enough about the latest curriculum standards and do not update their cognition of the latest content of mathematical reasoning ability in time. Regarding this issue, Wang SL finds that junior high school teachers can realize the importance of mathematical reasoning ability, but their understanding of it only stays in its meaning part, and their understanding of its performance is simple [5]. Thus hypothesis 2 is confirmed.

6.3 Cognitive Clarity

According to the above data analysis, it can be seen that current pre-service mathematics teachers' cognitive clarity is low, and their expression of junior high school mathematical

reasoning ability is vague. From this, we can see that the current pre-service mathematics teachers' cognitive clarity is low. The reason may be that the current university has not set up relevant training courses on mathematical reasoning ability, and the experts responsible for educating have not made requirements on the expression of mathematical reasoning ability of pre-service mathematics teachers, so most of the pre-service mathematics teachers can only understand part of the content of mathematical reasoning ability, and the expression is relatively vague. Regarding this question, Song interviews junior high school mathematical teachers and finds that although they have an understanding of mathematical reasoning ability, they can not accurately express the meaning and performances of mathematical reasoning ability [23]. Thus hypothesis 3 is confirmed.

7. CONCLUSION

In this study, through the investigation and analysis of the cognitive degree of junior high school mathematical reasoning ability of 25 pre-service mathematics teachers, it is found that the current pre-service mathematics teachers: 1. The cognitive breadth of junior high school mathematical reasoning ability is not wide, more than half of the people do not recognize half of the content, and their understanding focuses on the content with strong generality; 2. The cognitive depth of junior high school mathematical reasoning ability is generally low, the understanding of the meaning of mathematical reasoning ability is relatively deep, while the cognition of the performances is relatively simple. 3. The cognitive clarity of junior high school mathematical reasoning ability is low, and the expression is relatively vague.

Based on the above conclusions, it is suggested that teachers and experts responsible for educating teachers should pay more attention to junior high school mathematical reasoning ability and strengthen the training of pre-service mathematics teachers by adding relevant courses. For example, they can provide pre-service mathematics teachers with courses engaged in comprehensive training on assessment for learning to improve their higher-order algebraic thinking skills and thus enhance their mathematical reasoning ability [24]. Pre-service mathematics teachers themselves should take the initiative to study and research, improve their understanding of junior high school mathematical reasoning ability, carefully study

the *Curriculum Standards (2022 Edition)*, fully understand the relevant content of mathematical reasoning ability, and clarify the relevant statements.

The study's survey objects are 25 pre-service mathematics teachers, the sample size is relatively small. Meanwhile, the survey subjects are concentrated in the same university and do not involve pre-service mathematics teachers from other universities. Therefore, to find more detailed comprehensive results, it is necessary to expand the range of research samples to conduct more in-depth research. In addition, the results of this study provide a reference for the training content of pre-service mathematics teachers in other universities and countries, and the method of this study can be applied to other regions to investigate the cognitive degree of pre-service mathematics teachers on certain aspects of curriculum standards.

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CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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