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RESEARCH ON THE COGNITIVE DEGREE OF PRE-SERVICE HIGH SCHOOL MATHEMATICS TEACHERS FOR INTUITIVE IMAGINATION LITERACY

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ABSTRACT

Currently, many relevant problems about intuitive imagination literacy have been studied except the cognitive degree of pre-service high school mathematics teachers about it. To address this gap, this study investigates 51 pre-service high school mathematics teachers. Results showed that: 1. The cognitive scope of them about intuitive imagination literacy is not extensive, more than half of the content of intuitive imagination literacy is not recognized; 2. The cognition of many pre-service teachers is not deep or comprehensive and concentrates at a lower level; 3. The cognition of many pre-service teachers for many aspects of intuitive imagination literacy is not very clear. It is suggested that: 1. experts and teachers who are responsible for educating teachers should pay more attention to intuitive imagination literacy and add relevant courses; 2. pre-service high school mathematics teachers should understand the content of intuitive imagination literacy comprehensively and deeply, and clarify relevant statements.

Contribution/ Originality: This study analyzed the cognition degree of mathematical intuitive imagination literacy of current pre-service high school mathematics teachers in China with an open-ended questionnaire self-designed. The results are conducive to reforming the present Chinese teaching and curriculum in order to improve the training for pre-service teachers.

1. INTRODUCTION

Intuitive imagination is the literacy of using geometric intuition and spatial imagination to perceive the forms and changes of things, and using spatial forms, especially graphs, to understand and solve mathematical problems. In fact, not only the position relations and morphological changes of objects in our life are inseparable from intuitive imagination, but also mathematical thinking needs to be developed by means of intuition and imagination. In addition, intuitive imagination plays an important role in students' innovative spirit and practical ability, so its value in mathematics education cannot be underestimated (Zhang & Pei, 2020). Ministry of Education of the People's Republic of China (2018) promulgated by the Ministry of Education of the People's Republic of China in 2018 emphasized that intuitive imagination is an important means to discover and formulate, analyze and solve problems, and is the thinking basis for exploring and forming argumentation ideas, reasoning mathematically, and building abstract structures. At the same time, it is clearly stated that intuitive imagination literacy should be fully implemented at the high school level (Ministry of Education of the People's Republic of China, 2018). However,

after extensive discussions and studies by many scholars and teachers on the current situation of high school students' cognition of intuitive imagination literacy, it is found that the current level of intuitive imagination literacy among high school students is not high (Du, 2019), which showed that intuitive imagination literacy has not been well implemented in actual teaching. What are the reasons for this? How to develop students' intuitive imagination literacy? This is a question worthy of our study.

2. LITERATURE REVIEW

Currently, there have been many studies on this issue of implementing intuitive imagination literacy in high school mathematics teaching, and a literature review reveals that the relevant studies mainly focus on three aspects: the current situation of intuitive imagination literacy among high school students, the influencing factors and the cultivation strategies.

2.1. The Situation of High School Students' Intuitive Imagination Literacy Level

Before and after the promulgation of the Curriculum Standards (2017 edition), scholars investigated the current situation of high school students' imagination literacy level. In 2017, Weng (2017) found that the overall level of intuitive imagination literacy of high school students was not high, and the overall level was at Level 1. In addition, the number of students who could reach that level decreased as the level of intuitive imagination literacy increased level by level (Weng, 2017). This situation did not improve well after the promulgation of the new standard. In 2018, Chen (2018) found that the overall level of high school students' intuitive imagination literacy was low by testing students, and students' scores on the three dimensions of spatial imagination, number-shape combination, and geometric intuition declined in order (Chen, 2018). In 2019, Du (2019) mentioned in his study that according to the level quality test of the new standard, students' intuitive imagination literacy is not high, mainly concentrated in Level 1 and Level 2, and the number of those who have reached Level 3 is very small; in terms of the achieved levels, there is an uneven distribution of intuitive imagination literacy levels in all aspects (Du, 2019). In 2020, Zheng, Chen, Wang, and Lin (2020) also obtained similar findings to Du (2019), while they found that there were significant differences in the level of intuitive imagination literacy between boys and girls and uneven levels of intuitive imagination literacy among students from different geographical regions (Zheng et al., 2020). In 2021, Li (2021) further obtained through her study that there are three main deficiencies in the development of mathematical intuitive imagination literacy of high school students: they are unable to make precise identification of mathematical concepts related to intuitive imagination literacy; they are unable to show solid basic skills of graphing in describing practical problems with graphs; and they are unable to solve problems comprehensively with refined mathematical language according to problem characteristics (Li, 2021).

2.2. The Factors Affecting Students' Intuitive Imagination Literacy

Zhang and Pei (2020) analyzed the current situation and differences in the intuitive imagination of high school students and found that, on the one hand, the selection of the research subjects and the research method had some influence on the research results, and on the other hand, students' intuitive imagination showed gender differences gradually with age, but the gender differences shown by high school students were not yet stable (Zhang & Pei, 2020). Duan, Dong, and Chen (2021) used the teaching method as the independent variable to research and found that the experimental mathematics learning method of "doing mathematics" could significantly improve students' intuitive imagination, especially in chapters related to geometry (Duan et al., 2021). From the teacher's perspective, Du's study on the factors that improve students' intuitive imagination found that the following behaviors of teachers have a positive impact on students: (1) training students to observe real-world objects, models, and pictures; (2) allowing students to do more hands-on work and make models of Stereo graphics; (3) guiding students to abstract the observed objects and to imagine the shapes of objects from spatial figures (Du, 2019). A study by Lin

(2021) on the link between GeoGebra software and intuitive imagination literacy development concluded that the reasonable use of software that can demonstrate the generation and dynamic changes of mathematical elements in mathematics teaching is beneficial to the development of students' intuitive imagination literacy (Lin, 2021).

2.3. Strategies for Developing High School Students' Intuitive Imagination Literacy

At the macro level, some scholars have made a large number of suggestions on strategies for developing intuitive imagination literacy of high school students by integrating teachers, students, and textbooks. Zhang and Han (2017) suggested guiding students to observe spatial geometry, make models of spatial figures and accumulate representations of spatial figures, and developing students' spatial intuitive imagination literacy through students' hands-on practice and operational confirmation (Zhang & Han, 2017). Cheng (2020) gave four steps to cultivate students' intuitive imagination literacy based on the solution of quadratic equations: drawing operation, graphical understanding, experimental experience and numerical integration (Cheng, 2020). Chang (2020) summed up the triple realm of the penetration of intuitive imagination literacy in mathematics teaching: for teachers, they should incorporate their own teaching thinking on the basis of careful study of curriculum standards; for students, they should establish an intuitive model to obtain the improvement of students' thinking level through step-by-step teaching; for teaching: elementary mathematics should focus on the mastery of geometry, problem solving should pay attention to the charm of the combination of numbers and shapes, and analogical learning should seek the breakthrough of thinking innovation (Chang, 2020). Researching from the PME perspective, Shen and Wang (2017) proposed that in the teaching process, teachers should not only pay attention to the teaching of mathematics in the critical period, but also provide appropriate prior organizers, stimulate students' metacognitive monitoring and regulation, and design appropriate inquiry-based problems (Shen & Wang, 2017). At the micro level, scholars propose cultivation strategies through specific such as geometric figures, background materials, and other specific medium. Jin (2016) suggested that teachers must carefully study the tangents of background materials and the relationship with mathematical models in their teaching, use background materials rationally, and guide students to discover mathematical laws and models from them in order to solve problems (Jin, 2016). Cai (2019) proposed to use images to teach functions, to study geometric spatial position relationships using rectangles or squares, and to understand the relationship between vectors and geometry (Cai, 2019). By analyzing the main aspects of three-view teaching, Gao (2015) pointed out that three-view learning can improve students' spatial thinking ability, and it is also an effective path and means to improve students' intuitive imagination literacy (Gao, 2015). After conducting a study on the level of students' intuitive imagination ability, Li. (2019) suggested that the application of modern information technology in developing students' intuitive imagination should be emphasized (Li., 2019).

From the above studies, we can see that the previous studies on the current situation, influencing factors, and cultivation strategies of high school students' intuitive imagination literacy have been relatively mature, but we can also see from them that few studies have been conducted on teachers' intuitive imagination literacy, and the studies on the extent of teachers' cognitive degree of intuitive imagination literacy are in a gap. The improvement of students' intuitive imagination literacy is mainly achieved in school classroom teaching, and teachers are key players in developing students' core literacy (Du, 2019), so teachers' professionalism has a significant impact on students' intuitionistic ability (Yang, 2012). This shows that teachers' cognitive degree of intuitive imagination literacy is an important factor affecting students' intuitive imagination literacy. Therefore, the purpose of this study is to find out the current pre-service high school mathematics teachers' cognitive degree of intuitive imagination literacy through investigation.

Cognitive degree generally includes cognitive breadth, cognitive depth and cognitive clarity. Therefore, the main issues of this study are:

1. How wide is the cognitive degree of intuitive imagination literacy of pre-service high school mathematics teachers?

2. How deep is the cognitive degree of intuitive imagination literacy of pre-service high school mathematics teachers?
3. Is the current pre-service high school mathematics teachers' cognition of intuitive imagination literacy clear?

A number of current studies have shown that the current high school students' intuitive imagination literacy is not high, and the teacher's cognitive degree of intuitive imagination literacy is an important factor influencing students' intuitive imagination literacy. Therefore, the hypotheses of this study are:

Hypothesis 1: The current pre-service high school mathematics teacher's cognitive degree of the intuitive imagination literacy is not wide.

Hypothesis 2: The current pre-service high school mathematics teacher's cognitive degree of the intuitive imagination literacy is not deep.

Hypothesis 3: The current pre-service high school mathematics teacher's cognitive degree of the intuitive imagination literacy is not clear.

3. THEORETICAL BASIS

There have been many previous studies on what intuitive imagination literacy is and what its main components are.

Both Comenius and Pestalozzi were advocates of intuitionism, and they believed that intuition is a direct insight into the nature of things without sufficient logical reasoning, that is, a direct grasp of the object in its entirety. Klein (1979) believed that intuition in mathematics is the direct grasp of concepts and proofs (Klein, 1979). In 2011, Ministry of Education of the People's Republic of China (2011) proposed that teachers should initially build students' spatial concepts in teaching and enable them to develop their figurative thinking (Ministry of Education of the People's Republic of China, 2011). On the basis of this, Professors (Kong & Shi, 2012) further interpreted "geometric intuition" as the ability to directly perceive and grasp the objects of mathematics (spatial forms and quantitative relationships) with the help of the visual relations of geometric figures seen (or imagined). In primary and secondary school mathematics, geometric intuition can be expressed in four forms: physical intuition, simple symbolic intuition, graphical intuition and substitution intuition (Kong & Shi, 2012). The "General High School Mathematics Curriculum Standards (Experimental)" promulgated in 2003 states that the cultivation and development of students' spatial imagination, ability to reason and argue, ability to use graphic language to communicate, and geometric intuition at the high school level are the basic requirements of the required series of mathematics courses at the high school level (Ministry of Education of the People's Republic of China, 2003). At this point, the compulsory education level and the general high school level have reached unification, and intuitive imagination appears in the mathematics curriculum objectives in the form of spatial imagination ability.

Subsequently, more and more scholars and experts have studied the connotation and structure of intuitive imagination literacy. Shen and Wang (2017) believe that intuitive imagination is the basic way to know things. Unlike abstraction, intuitive imagination is simple, direct, easy to grasp and use. At the same time, it is the necessary basis for further abstraction. In short, intuitive imagination is to look at a picture and think about it, to see it and reason about it Shen and Wang (2017). According to Sun (2017), "intuitive imagination" as a mathematical literacy is a parallel and abbreviated phrase, the full version of which is "geometric intuition and spatial imagination". Geometric intuition is the perceptual understanding through geometric figures, and spatial imagination is the imagination of spatial forms. Spatial imagination provides the method for geometric intuition, and geometric intuition provides the cognitive basis for spatial imagination, so the two form a nested cycle of interaction (Sun, 2017). Mi and Cui (2018) also divided intuitive imagination into geometric intuition and spatial imagination, and further divided spatial imagination into three levels: awareness of space, understanding imagination, and spatial imagination (Mi & Cui, 2018).

The Ministry of Education of the People's Republic of China comprehensively summarized the above viewpoints, and gave the most formal statement in the latest version of the "Curriculum Standards (2017 Edition)" promulgated in January 2018. The new curriculum standard points out that intuitive imagination refers to the literacy of using geometric intuition and spatial imagination to perceive the forms and changes of things, and using spatial forms, especially graphs, to understand and solve mathematical problems.

Intuitive imagination literacy mainly includes: recognizing the position relationship, morphological changes and laws of motion of things with the help of spatial forms; using graphics to describe and analyze mathematical problems; establishing the connection between shapes and numbers, constructing intuitive models of mathematical problems, and exploring ideas for solving problems. In addition, it clearly expounds the mathematical value and main performance of the intuitive imagination literacy, and requirements that students can reach through high school mathematics courses.

Intuitive imagination is mainly manifested as: establishing the connection between shapes and numbers, describing problems using geometric figures, understanding problems with the help of geometric intuition, and using spatial imagination to recognize things. Through the learning of high school mathematics course, students can enhance the ability of combining numbers and shapes, develop geometric intuition and spatial imagination; enhance the awareness of using geometric intuition and spatial imagination to think about problems; form mathematical intuition and perceive the essence of things in a concrete situation.

Finally, the three levels of intuitive imagination literacy are stipulated in terms of four aspects: Situation and Question, Knowledge and Skills, Thinking and Expression, and Communication and Reflection, and a corresponding framework of literacy levels has been established, with Level 1 facing the high school entrance exam, Level 2 facing the college entrance exam, and Level 3 facing the independent college entrance exam. In terms of the aspect of Situation and Question, Level 1 is to be able to abstract the geometric figures of objects in a familiar situation, establish the connection between simple figures and objects, and experience the relationship between figures and figures, figures and quantities; Level 2 is to be able to imagine and construct corresponding geometric figures in a related situation, to be able to propose mathematical questions with the help of figures, discover the relationship between figures and figures, figures and quantities, and explore the laws of motion of figures; Level 3 is to be able to propose mathematical questions with the help of figures and intuitive imagination in an integrated situation. In terms of the aspect of Knowledge and Skills, Level 1 is to be able to discover mathematical laws in familiar mathematical situations with the help of properties and transformations (translation, symmetry, rotation) of figures, to be able to describe the positional and metric relations of simple figures and their specific properties; Level 2 is to be able to master the basic methods of studying the relationship between figures and figures, figures and quantities, to be able to explore mathematical laws with the help of properties of figures, to solve practical problems or mathematical problems.

Level 3 is to be able to make comprehensive use of the relationship between figures and figures, figures and quantities, to understand the connection between the various branches of mathematics, to be able to establish the connection between mathematics and other disciplines with the help of intuitive imagination, and to form an intuitive model of the theoretical system. In terms of the aspect of Thinking and Expression, Level 1 is to be able to understand mathematical problems through graphical intuition, to be able to describe and express familiar mathematical problems with graphs, to inspire ideas for solving these problems, and to experience the combination of numbers and shapes; Level 2 is to be able to propose mathematical problems through intuitive imagination, to be able to explore ideas for solving problems with graphs, to be able to form the idea of combining numbers and shapes, and to experience the role and significance of geometric intuition; Level 3 is to be able to express complex mathematical problems intuitively through imagination, reflect the nature of mathematical problems, and form ideas for solving them.

In terms of the aspect of Communication and Reflection, Level 1 refers to be able to use graphical intuition to communicate in daily life; Level 2 refers to be able to use intuitive imagination to explore mathematical problems during communication; Level 3 refers to be able to use intuitive imagination to explore the nature of problems and the connection with mathematics during communication (Ministry of Education of the People's Republic of China, 2018). In order to ensure the objectivity of the research, this study adopts the definition of intuitive imagination literacy from Curriculum Standards (2017 Edition) to conduct research on the cognitive degree of intuitive imagination literacy of pre-service high school mathematics teachers.

4. RESEARCH METHODS

4.1. Participants

In order to faithfully reflect the pre-service high school mathematics teachers' cognitive degree of intuitive imagination literacy, this study selected 51 masters of education majoring mathematics of grade 2021 from the School of Mathematics and Statistics of Shandong Normal University as the survey sample that include 3 boys and 48 girls, all of whom hold high school mathematics teacher qualification certificates and have the intention to go to high school for employment in the future.

4.2. Instrument

In this study, the open-ended interview method was used to investigate, and the interview outline was designed with one question, "How do you understand intuitive imagination literacy? Please tell us your understanding in detail and comprehensively." The reason for choosing this question is to find out the pre-service high school mathematics teachers' real cognitive situation of intuitive imagination literacy. The open-ended interview method is adopted because it is fast, convenient, flexible, not restricted by written language, and it facilitates in-depth investigations to obtain the most direct information.

4.3. Data Collection

In order to ensure the reliability of the research, the open-ended interview method was used to interview 51 masters of education one by one individually, and the interview content was recorded during the whole process after the consent of the other party was sought.

4.4. Data Processing

Firstly, the content of the appendix of the Curriculum Standards (2017 edition) about intuitive imagination literacy was divided and coded. Use A, B, C, and D to represent the four aspects of Situation and Question, Knowledge and Skills, Thinking and Expression and Communication and Reflection. Then according to three levels, the above content is coded as 1, 2 and 3. Finally, E, F, G and H are used to represent the meaning of intuitive imagination literacy, the main content, the main performance and the requirements that students can reach through high school mathematics courses. In this way, a total of 8 aspects from A to H and 46 points from A11 to H15 are divided, which are shown in Table 1.

Afterwards, we converted the interview recording content into text form, removed um, ah and other discourse markers, strictly followed the original words of the interview to sort out, and compared with the encoded content one by one. If the content is similar in meaning, the survey object is considered to be able to recognize this point. In addition, the cognitive degree is judged based on the completeness and accuracy of the survey subjects' expressions. Finally, we count the number of people mentioning it for each point, calculate the corresponding percentage, and make a statistical table.

Table 1. Content coding.

Category		Label	Content
A. Situation and Question	A1 Level 1	A11	Be able to abstract the geometric figures of objects in a familiar situation
		A12	Establish the connection between simple figures and objects
		A13	Experience the relationship between figures and figures, figures and quantities
	A2 Level 2	A21	Be able to imagine and construct corresponding geometric figures in a related situation
		A22	Be able to propose mathematical questions with the help of figures
		A23	Discover the relationship between figures and figures, figures and quantities
		A24	Explore the laws of motion of figures
	A3 Level 3	A31	Be able to propose mathematical questions with the help of figures and intuitive imagination in an integrated situation.
B. Knowledge and Skills	B1 Level 1	B11	Be able to discover mathematical laws in familiar mathematical situations with the help of properties and transformations (translation, symmetry, rotation) of figures
		B12	Be able to describe the positional and metric relations of simple figures and their specific properties
	B2 Level 2	B21	Be able to master the basic methods of studying the relationship between figures and figures, figures and quantities
		B22	Be able to explore mathematical laws with the help of properties of figures
		B23	Solve practical problems or mathematical problems
	B3 Level 3	B31	Be able to make comprehensive use of the relationship between figures and figures, figures and quantities, to understand the connection between the various branches of mathematics
		B32	To be able to establish the connection between mathematics and other disciplines with the help of intuitive imagination
		B33	Form an intuitive model of the theoretical system.
C. Thinking and Expression	C1 Level 1	C11	Be able to understand mathematical problems through graphical intuition
		C12	To be able to describe and express familiar mathematical problems with graphs
		C13	Inspire ideas for solving these problems
		C14	Experience the combination of numbers and shapes
	C2 Level 2	C21	Be able to propose mathematical problems through intuitive imagination
		C22	Be able to explore ideas for solving problems with graphs
		C23	Be able to form the idea of combining numbers and shapes
		C24	Experience the role and significance of geometric intuition
	C3 Level 3	C31	Be able to express complex mathematical problems intuitively through imagination
		C32	Reflect the nature of mathematical problems
		C33	Form ideas for solving problems
D. Communication and Reflection	D1 Level 1	D11	Be able to use graphical intuition to communicate in daily life
	D2 Level 2	D21	Be able to use intuitive imagination to explore mathematical problems during communication
	D3 Level 3	D31	Be able to use intuitive imagination to explore the nature of problems and the connection with mathematics during communication.
E. Meaning		E1	Use geometric intuition and spatial imagination to perceive the forms and changes of things
		E2	Use spatial forms, especially graphs, to understand and solve mathematical problems.
F. Main Content		F1	Recognize the position relationship, morphological changes and laws of motion of things with the help of spatial forms
		F2	Use graphics to describe and analyze mathematical problems
		F3	Establish the connection between shapes and numbers

Category	Label	Content
	F4	Construct intuitive models of mathematical problems
	F5	Explore ideas for solving problems
G. Main Performance	G1	Establish the connection between shapes and numbers
	G2	Describe problems using geometric figures
	G3	Understand problems with the help of geometric intuition
	G4	Use spatial imagination to recognize things
H. Requirements	H1	Enhance the ability of combining numbers and shapes
	H2	Develop geometric intuition and spatial imagination
	H3	Enhance the awareness of using geometric intuition and spatial imagination to think about problems
	H4	Form mathematical intuition
	H5	Perceive the essence of things in a concrete situation

5. RESULTS

5.1. Cognitive Breadth

Among 46 points of intuitive imagination literacy mentioned in Curriculum Standards (2017 Edition), pre-service high school mathematics teachers can recognize 20 points, accounting for 43.48% of the total. The highest number of pre-service teachers who recognize it was "Use spatial forms, especially graphs, to understand and solve mathematical problems", with 20 students, accounting for 39.22% of the total.

In terms of different aspects, Situation and Question is divided into 8 points, of which 3 points are recognized; Knowledge and Skills is divided into 8 points, of which 1 points are recognized; Thinking and Expression is divided into 11 points, of which 3 points are recognized; Communication and Reflection is divided into 3 points, but 0 point is recognized. In terms of different levels, there are 10 points in Level 1, of which 4 points are recognized; there are 12 points in Level 2, of which 3 points are recognized; there are 8 points in Level 3, of which 0 point is recognized. At the same time, the "Meaning" of intuitive imagination literacy is divided into 2 points, all of which are recognized; "Main Content" is divided into 5 points, of which 4 points are recognized; "Main Performance" is divided into 4 points, of which 3 points are recognized; "Requirements" is divided into 5 points, of which 4 points are recognized.

It can be seen that the current pre-service high school mathematics teachers do not have a wide range of cognition about the intuitive imagination literacy, and more than half of its content of is not recognized. At the same time, their cognition is concentrated on some individual points, and their cognitive degree of the more general content of intuitive imagination literacy is higher, such as "Meaning", "Main Content", "Requirements" and so on, while the cognitive degree of some details specified in the Curriculum Standards (2017 Edition) is lower. The details are shown in Table 2.

5.2. Cognitive Depth

Further analysis of the four aspects of the three levels reveals that, in terms of different levels, pre-service high school mathematics teachers know more about Level 1, and 40.00% points of the total points of this level are recognized. At the same time, 25.00% points of Level 2 are recognized, but nothing about Level 3 is recognized. In terms of different aspects, most of the points they recognized were in "Situation and Problem" and "Thinking and Expression", with 3 points each, accounting for 37.50% and 27.27% of their aspects respectively, while only 12.50% of the points in "Knowledge and Skills" were recognized, and "Communication and Reflection" was not recognized at all.

At the same time, pre-service high school mathematics teachers recognize up to 100.00% of the "Meaning" of intuitive imagination literacy. At the same time, they recognized 80.00% of the "Main Content" and "Requirements" respectively, and they recognized 75.00% of the aspect of "Main Performance".

Table 2. Cognitive breadth results.

Category		Label	Number	Percentage (%)	Cognitive points	Total points	Percentage (%)
A. Situation and Question	A1 Level 1	A11	6	11.76	2	3	66.67
		A12	8	15.69			
		A13	0	0.00			
	A2 Level 2	A21	4	7.84	1	4	25.00
		A22	0	0.00			
		A23	0	0.00			
		A24	0	0.00			
	A3 Level 3	A31	0	0.00	0	1	0.00
B. Knowledge and Skills	B1 Level 1	B11	0	0.00	0	2	0.00
		B12	0	0.00			
	B2 Level 2	B21	1	1.96	1	3	33.33
		B22	0	0.00			
		B23	0	0.00			
	B3 Level 3	B31	0	0.00	0	3	0.00
		B32	0	0.00			
		B33	0	0.00			
C. Thinking and Expression	C1 Level 1	C11	1	1.96	2	4	50.00
		C12	0	0.00			
		C13	0	0.00			
		C14	3	5.88			
	C2 Level 2	C21	0	0.00	1	4	25.00
		C22	0	0.00			
		C23	3	5.88			
		C24	0	0.00			
	C3 Level 3	C31	0	0.00	0	3	0.00
		C32	0	0.00			
		C33	0	0.00			
D. Communication and Reflection	D1 Level 1	D11	0	0.00	0	1	0.00
	D2 Level 2	D21	0	0.00	0	1	0.00
	D3 Level 3	D31	0	0.00	0	1	0.00
E. Meaning		E1	15	29.41	2	2	100.00
		E2	20	39.22			
F. Main Content		F1	6	11.76	4	5	80.00
		F2	2	3.92			
		F3	2	3.92			
		F4	2	3.92			
		F5	0	0.00			
G. Main Performance		G1	1	1.96	3	4	75.00
		G2	1	1.96			
		G3	1	1.96			
		G4	0	0.00			
H. Requirements		H1	1	1.96	4	5	80.00
		H2	1	1.96			
		H3	1	1.96			
		H4	1	1.96			
		H5	0	0.00			

It can be seen that the current pre-service teachers have a deep and comprehensive cognition of the "Meaning" and other general content of the intuitive imagination literacy, while their cognition of the three levels and four aspects is relatively superficial or incomplete. On the whole, the current pre-service high school mathematics teachers' cognition degree of intuitive imagination literacy is relatively superficial, mainly focusing on the lower levels. The details are shown in Table 3 and Table 4.

Table 3. Cognitive depth results for three levels and four aspects.

Category	Level 1	Level 2	Level 3
A. Situation and Question	66.67	25.00	0.00
B. Knowledge and Skills	0.00	33.33	0.00
C. Thinking and Expression	50.00	25.00	0.00
D. Communication and Reflection	0.00	0.00	0.00

Table 4. Cognitive depth results for other content.

Category	E Meaning	F Main Content	G Main Performance	H Requirements
Percentage (%)	100.00	80.00	75.00	80.00

5.3. Cognitive Clarity

We judged the cognitive degree based on the completeness and accuracy of the expressions of the survey subjects in each content, and calculated the percentages of the number of people with high and low levels of cognition to the total number of people. Through investigation, it is found that the current pre-service high school mathematics teachers' cognition is clearest in terms of "Establish the connection between shapes and numbers", "Describe problems using geometric figures" and other 6 points. Although there are not many people who recognize the above these points, the percentage of cognitive clarity has reached 100.00:0.00, accounting for 13.04% of the total points. On the contrary, the pre-service teachers' cognition is most ambiguous in terms of "Be able to abstract the geometric figures of objects in a familiar situation" and other 8 points, and the cognitive clarity percentage is 0.00: 100.00, accounting for 17.39% of the total points.

It can be seen that current pre-service high school mathematics teachers have fewer points of clear understanding about intuitive imagination literacy. In terms of the points recognized by the pre-service teachers, there are clear about some individual points in the "Main Performance" and "Requirements", while the other points either are not recognized or are recognized vaguely. Overall, the cognition of intuitive imagination literacy of pre-service high school mathematics teachers is not clear. The details are shown in Table 5.

6. DISCUSSION

6.1. Cognitive Breadth

According to the above data analysis, it can be seen that the current pre-service high school mathematics teachers do not have a wide range of cognition about the intuitive imagination literacy, and more than half of the content of intuitive imagination literacy are not recognized. At the same time, their cognition is concentrated on some individual points, and their cognitive degree of the more general content of intuitive imagination literacy is higher, such as "Meaning", "Main Content", "Requirements" and so on, while the cognitive degree of some details specified in the Curriculum Standards (2017 Edition) is lower. From this we can see that the current pre-service high school mathematics teachers do not have a wide range of cognition of intuitive imagination literacy. Regarding this issue, Quan (2021) found through his study that teachers' cognitive degree of core literacy in mathematics is at a moderate to low level, and they do not pay much attention to intuitive imagination literacy, in addition, their awareness of its value and their research intention are also insufficient (Quan, 2021). Thus hypothesis 1 is confirmed.

6.2. Cognitive Depth

According to the above data analysis, it can be seen that the current pre-service teachers have a deep and comprehensive cognition of the "Meaning" and other general content of the intuitive imagination literacy, while their cognition of the three levels and four aspects is relatively superficial or incomplete. On the whole, the current pre-service high school mathematics teachers' cognition degree of intuitive imagination literacy is relatively superficial, mainly focusing on the lower levels.

Table 5. Cognition clarity results.

Category		Label	Percentage of cognitive clarity (High degree: low degree)
A. Situation and Question	A1 Level 1	A11	0.00 : 100.00
		A12	0.00 : 100.00
		A13	0.00 : 0.00
	A2 Level 2	A21	0.00 : 100.00
		A22	0.00 : 0.00
		A23	0.00 : 0.00
		A24	0.00 : 0.00
	A3 Level 3	A31	0.00 : 0.00
B. Knowledge and Skills	B1 Level 1	B11	0.00 : 0.00
		B12	0.00 : 0.00
	B2 Level 2	B21	0.00 : 100.00
		B22	0.00 : 0.00
		B23	0.00 : 0.00
	B3 Level 3	B31	0.00 : 0.00
		B32	0.00 : 0.00
		B33	0.00 : 0.00
C. Thinking and Expression	C1 Level 1	C11	0.00 : 100.00
		C12	0.00 : 0.00
		C13	0.00 : 0.00
		C14	66.67 : 33.33
	C2 Level 2	C21	0.00 : 0.00
		C22	0.00 : 0.00
		C23	0.00 : 100.00
		C24	0.00 : 0.00
	C3 Level 3	C31	0.00 : 0.00
		C32	0.00 : 0.00
		C33	0.00 : 0.00
D. Communication and Reflection	D1 Level 1	D11	0.00 : 0.00
	D2 Level 2	D21	0.00 : 0.00
	D3 Level 3	D31	0.00 : 0.00
E. Meaning		E1	73.33 : 26.67
		E2	35.00 : 65.00
F. Main Content		F1	0.00 : 0.00
		F2	50.00 : 50.00
		F3	50.00 : 50.00
		F4	0.00 : 100.00
		F5	0.00 : 0.00
G. Main Performance		G1	100.00 : 0.00
		G2	100.00 : 0.00
		G3	100.00 : 0.00
		G4	0.00 : 0.00
H. Requirements		H1	100.00 : 0.00
		H2	100.00 : 0.00
		H3	0.00 : 100.00
		H4	100.00 : 0.00
		H5	0.0 : 0.00

From this we can see that the overall cognition of pre-service high school mathematics teachers in intuitive imagination literacy is superficial. Regarding this issue, Zhao and Pan (2021) had found through their survey that many high school mathematics teachers were not highly literate in the subject of mathematics (Zhao & Pan, 2021). Similarly, Du (2019) found in his study that there was a widespread lack of knowledge, understanding and attention to intuitive imagination literacy among teachers, and teachers are not sufficiently aware of the different levels of visual imagination literacy achieved by different students (Du, 2019). Thus hypothesis 2 is confirmed.

6.3. Cognitive Clarity

According to the above data analysis, it can be seen that current pre-service high school mathematics teachers have fewer points of clear understanding about intuitive imagination literacy. In terms of the points recognized by the pre-service teachers, there are clear about some individual points in the "Main Performance" and "Requirements", while the other points either are not recognized or are recognized vaguely. Overall, the cognition of intuitive imagination literacy of pre-service high school mathematics teachers is not clear. From this we can see that the current pre-service high school mathematics teachers have low cognitive clarity on the intuitive imagination literacy.

Regarding this issue, in the study of the factors influencing intuitive imagination literacy in teaching, Feng (2020) found that teachers have a vague understanding of the connotation as well as the specific content of intuitive imagination proposed by the new standards (Feng, 2020). Thus hypothesis 3 is confirmed.

7. CONCLUSION

It has been shown that teachers' cognitive degree of intuitive imagination literacy directly affects the formation of students' intuitive imagination literacy. The current high school students' intuitive imagination literacy is generally not high, so is it because teachers' cognitive degree of intuitive imagination literacy is not high? For this reason, 51 masters of education were selected for this study, and the pre-service high school mathematics teachers' cognitive degree of intuitive imagination literacy was investigated by the method of open-ended interviews. Through investigation and analysis, it can be seen that: 1. The pre-service high school mathematics teachers recognize less than half of the content of intuitive imagination literacy, and their cognitive scope of intuitive imagination literacy is not wide, mainly focusing on the content with relatively strong generality; 2. The pre-service teachers' overall cognition of intuitive imagination literacy is superficial, mainly focusing on the lower levels, while the cognition of some of the content with strong generality is deeper and more comprehensive; 3. The pre-service teachers' overall cognitive clarity of intuitive imagination literacy is low, with fewer points clearly recognized and most other points either not recognized or vaguely recognized.

According to the above conclusions, it is recommended: 1. Relevant teachers and experts who train pre-service high school mathematics teachers should increase the emphasis on intuitive imagination literacy, add relevant courses, and strengthen the training in this area for pre-service high school mathematics teachers; 2. pre-service high school mathematics teachers should take the initiative to study and research to improve their understanding of intuitive imagination literacy, so as to: (1) Fully understand the relevant content of intuitive imagination literacy; (2) Understand each level and aspect of intuitive imagination literacy deeply; (3) Clarify the expression of intuitive imagination literacy.

The research object of this study is 51 masters of education, which is a relatively small sample size. At the same time, the sample is only limited to one grade and one school, and other types of pre-service high school mathematics teachers are not involved, which is a narrow sample selection. Therefore, in order to find more detailed and comprehensive results, it is necessary to expand the scope of the research sample and adopt a variety of research methods to conduct a more in-depth study.

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