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# RESEARCH ON THE COGNITIVE DEGREE OF PRE-SERVICE HIGH SCHOOL MATHEMATICS TEACHERS ON THE IMPLEMENTATION FOR MATHEMATICAL MODELING LITERACY

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## ABSTRACT
Currently, mathematical modeling literacy has attracted more and more attention from all walks of life. Many relevant problems about it have been studied except the cognitive degree of pre-service high school mathematics teachers on the implementation for mathematical modeling literacy. This study investigates 51 pre-service high school mathematics teachers' cognitive degree of mathematical modeling literacy by using the method of open interview. After analyzing, it is found that: 1. The scope of cognition of the current pre-service high school mathematics teachers on the implementing for mathematical modeling literacy is not wide, and more than half of the content on the implementing for mathematical modeling literacy previously proposed has not been realized by many pre-service teachers yet; 2. The cognitive content focuses on the connection between mathematical modeling and real life; 3. The cognition of many pre-service teachers is not reasonable and lacks feasibility or effectiveness, which needs to be further explored and thought. Therefore, it is suggested that: 1. Experts and teachers responsible for training work should provide more teaching practice opportunities for pre-service teachers; 2. Pre-service teachers should pay attention to observing students' learning status in the process of practice, reflect on whether their cultivation strategies are reasonable, and then make further adjustments according to the actual situation of the school and classroom.

**Key Words**: Pre-service teacher, Mathematics, Modeling literacy, High school, Training strategy.

## 1. INTRODUCTION
Mathematical modeling is the literacy to mathematically abstract real problems, express problems in mathematical language, and use mathematical methods to build models to solve problems. With the rapid development of the information age and big data age, the application of mathematical knowledge to solve problems in real life will also become the trend of mathematical education in the future. Mathematical modeling in mathematical core literacy is the bridge between real life and mathematical theory. Therefore, teachers should put the cultivation of students' mathematical modeling literacy in an important position. However, through questionnaires, interviews and other methods, predecessors investigated the mathematical modeling literacy of senior high school students in different regions and grades, and found that the current mathematical modeling literacy

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of senior high school students is generally not high. What is the reason for this? How to cultivate students' mathematical modeling literacy? This is a problem worth studying.

## 2. LITERATURE REVIEW

There have been many studies on the mathematical modeling literacy of senior high school students.

### 2.1 Cognitive Status of Mathematical Modeling Literacy of Senior High School Students

Zhu (2020) selected a provincial demonstration high school in Henan Province to investigate the current situation of students' mathematical modeling, and found that the current students' mathematical modeling literacy is concentrated at the medium level, and nearly 90% of the students' mathematical modeling literacy needs to be further improved (Zhu, 2020). Song (2019) investigated some classes of students in three senior high schools in Shijiazhuang and found that the level of students' mathematical modeling literacy is low, and the average level is about Level 1 (Song, 2019). Through the research methods of questionnaire and interview, Chen (2019) randomly selected two classes of 200 students in two middle schools in Xiamen to implement the survey and found that the overall mathematical modeling literacy of senior students was not optimistic, and the channels that students could access to mathematical modeling were very limited (Chen, 2019). With the help of 5 test questions and 12 questionnaire questions, Ye (2018) investigated high school students and found that about 70% of the students were at level 1 and level 2 of mathematical modeling literacy, with low comprehensive performance (Ye, 2018). Tang (2018) took senior high school students in Fuzhou as the research object and found that their mathematical modeling literacy is at the first level. They can only peel off a small part of mathematics related information from the topic. The obtained mathematical model is very different from the reality, and it is difficult to get appropriate mathematical answers and Solutions to practical problems (Tang, 2018). Li (2017) investigated high school students in Nanning District, Guangxi, and found that the development of mathematical modeling literacy of high school students in various schools in this area is not optimistic, the training of schools is uneven, and the modeling literacy of high school students is at a low level as a whole (Li, 2017).

### 2.2 Influencing Factors of Mathematical Modeling Literacy of Senior High School Students

Liu (2020) studied the relevant factors affecting students' mathematical modeling literacy from four aspects: mathematical cognitive structure, mathematical modeling emotion, self-monitoring and teachers' influence, and found that teachers have the greatest impact on students (Liu, 2020). Sun (2019) finds that teachers' teaching is the main factor affecting students' mathematical modeling literacy. At present, the main problems are: Teachers' understanding of mathematical modeling is biased; Teachers are lack of knowledge reserves and resources in mathematical modeling (Sun, 2019). Ye (2018) conducted case interviews with front-line teachers in high schools and learned that teachers have a vague understanding of mathematical modeling literacy and usually lack the examination of students' mathematical modeling literacy (Ye, 2018). Tang (2017) finds that the main reasons for the current low literacy of high school students in mathematical modeling are teachers' lack of overall grasp and in-depth research on the design of mathematical modeling teaching contents in textbooks, teachers' less clear teaching objectives and learning goals for each stage of mathematical modeling, and teachers' low comprehensive literacy (Tang, 2017).

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### 2.3 Cultivation Strategy of Mathematical Modeling Literacy of Senior High School Students

In view of the problems existing in the course of mathematical modeling in senior high school mathematics teaching, Zhang (2020) puts forward three training suggestions: Infiltrating the consciousness of mathematical modeling; Pay attention to the key steps of modeling; Improve the evaluation and investigation mechanism (Zhang, 2020). Ji (2020) proposes three constructs for the cultivation strategies of mathematical modeling: Curriculum construction for modeling literacy cultivation; Teaching and learning strategies for modeling literacy cultivation; Faculty optimization for modeling literacy cultivation (Ji, 2020). By studying the development of the connotation of mathematical modeling in Chinese mathematics curriculum standards since the 20th century, Huang et al. (2019) put forward three suggestions for future teaching practice: Comprehensively cultivate the sub abilities of mathematical modeling; Pay attention to the help of modeling to mathematical knowledge; Pay attention to the evaluation of mathematical modeling ability (Huang et al., 2019). Combined with their own teaching practice, Kong et al. (2019) and others put forward two effective paths: Based on the optimization of problem situation setting, effectively apply information technology and experience the complete modeling process; Strengthen the basic idea of student model and improve students' model solving ability (Kong et al., 2019). Yu (2018) proposes that in the teaching process, teachers should help students summarize the basic models of mathematical modeling, make them have a systematic understanding of knowledge and methods, and design the modeling of some open problems (Yu, 2018). Chen (2017) analyzes the development of students' mathematical modeling literacy from the perspective of PME and gives training strategies from three angles: Providing students with cognitive scaffolding from the perspective of connotation understanding; Provide students with opportunities for interactive communication from the perspective of participation process; Provide targeted feedback for students from the perspective of level evaluation (Chen, 2017). Tang (2017) proposes that high school mathematics teaching can be done through four ways: classroom teaching, mathematical modeling elective, extracurricular modeling extension and mathematical modeling competition activities, using "compulsory" "elective" "practical class "The four ways of "competition class" are to cultivate students' mathematical modeling literacy in three dimensions: cultural foundation, independent development and social participation (Tang, 2017).

### 2.4 Evaluation Method of Mathematical Modeling Literacy of Senior High School Students

On the basis of referring to the "mathematical literacy evaluation framework", Liu (2020) constructs the evaluation framework of mathematical modeling literacy from the four dimensions of modeling knowledge, modeling situation, modeling ability and modeling cognition (Liu, 2020). Yan (2020) learns from the construction methods of the existing education evaluation system and establishes the mathematical modeling literacy evaluation system from the three dimensions of understanding, application and innovation (Yan, 2020). Lin et al. (2019) divides the mathematical model into three levels "single structure model, correlation structure model and expansion structure model", and then corresponds the students' mathematical modeling literacy level with the established mathematical model one by one, so as to construct the students' mathematical modeling literacy evaluation model (Lin et al., 2019). Lu et al. (2019) proposes a mathematical modeling literacy framework combining process and result. Process evaluation is to evaluate the modeling steps experienced by students, and result evaluation is to evaluate the modeling ability level achieved by students (Lu et al., 2019).

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It can be seen from the above studies that predecessors have conducted various studies on senior high school students' mathematical modeling literacy, and some studies have been relatively rich, such as the research on training strategies, scholars have given a variety of programs. However, it is also clear from this that there are some areas that have not been addressed, such as the lack of in-depth research on the understanding of pre-service high school mathematics teachers on the implementation of mathematical modeling literacy, and it would undoubtedly be meaningful to research this aspect. It is clear from previous studies that pre-service teachers in the previous education model learn from some previous experiences, but educational theories need to be constantly supplemented and improved, and pre-service teachers need to summarize the laws and experiences by themselves. So do they know how to implement mathematical modeling literacy? Are their teaching suggestions practical? Therefore, this paper intends to study the pre-service high school mathematics teachers' understanding of the implementation of mathematical modeling literacy from two dimensions, mainly to find out their understanding of the implementation of mathematical modeling literacy in general teaching and specific teaching.

Therefore, the main problems studied in this paper are:

1. How widespread is the current awareness of pre-service high school mathematics teachers regarding the implementation of mathematical modeling literacy?

2. In what areas do current pre-service high school mathematics teachers' awareness of implementing mathematical modeling literacy focus?

3. Is the current awareness of pre-service high school mathematics teachers about implementing mathematical modeling literacy reasonable?

## 3. METHODS

### 3.1 Sample

In order to investigate the understanding of pre-service high school mathematics teachers on the implementation of mathematical modeling literacy, this study selects 51 students with 2021 master of education from the school of Mathematics and Statistics of Shandong Normal University. They have high school teacher qualification certificate and have obvious intention to teach in high school. Among them, the number of female students accounts for 94.12% and the number of male students accounts for 5.88%.

### 3.2 Instrument

This study investigates the master of education's cognition of mathematical modeling literacy through open-ended interview. There are two interview questions: 1. How do you think mathematical modeling literacy should be implemented in middle school? 2. How do you think to implement mathematical modeling literacy in class? The reason why these two questions are used as the interview content is to investigate whether they know how to implement mathematical modeling literacy in senior high school, and whether their understanding is feasible and effective. At the same time, data collection with the help of interview method can obtain direct and reliable information, which is not limited by written language and is easy to conduct in-depth investigation.

### 3.3 Data Collection

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In this study, 51 masters of education are interviewed one by one through open-ended interview, and the interview content is recorded after soliciting the consent of them.

### 3.4 Data Processing

The collected recordings are converted into text and sorted out. In the process of sorting out, in order to retain the original intention of the respondents, no change is made, only modal particles such as uh ah are removed. After that, it makes a comprehensive arrangement and statistics on the understanding of master of education with the method of coding.

## 4. RESULT

### 4.1 Cognitive Scope

The statements of master of education are summarized as 28 points. There are 19 points on how to implement them in middle school and 9 points on how to implement them in class. This study arranges the training strategies of mathematical modeling literacy put forward by predecessors, and a total of 53 points are sorted out. See Table 1 for details.

**Table 1 Coding of training strategies proposed by predecessors**

| Primary index | Secondary index | Symbol | Viewpoint |
|---|---|---|---|
| How to implement it in middle school | A School | A1 | Innovate idea |
| | | A2 | Optimize the resource allocation of school mathematical modeling |
| | | A3 | Encourage school-based research on mathematical modeling |
| | | A4 | Develop mathematical modeling cases in teaching materials |
| | | A5 | Create academic environment of mathematical modeling |
| | | A6 | Set up mathematical modeling activity course |
| | | A7 | Improve the evaluation mechanism of mathematical modeling |
| | | A8 | Organize mathematical modeling activities |
| | | A9 | Strengthen the relevant training of mathematical modeling |
| | B Teacher | B1 | Improve the awareness of mathematical modeling |
| | | B2 | Strengthen the learning of modeling software |
| | | B3 | Sort out the appropriate mathematical modeling data |
| | | B4 | Train students' modeling thinking |
| | | B5 | Encourage students to enter life and cultivate the vision of “discovering mathematics” |
| | | B6 | Design the modeling of some open problems |
| | | B7 | Cultivate students' model building ability |
| | | B8 | Take the modeling problem of design mathematics as the teaching countermeasure |
| | | B9 | Focus on key steps of modeling |
| | | B10 | Improve the evaluation and examination mechanism |

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| | | B11 | Pay attention to the help of modeling to mathematical knowledge |
| | | B12 | Help students summarize the basic models of mathematical modeling and form the systematicness of knowledge |
| | | B13 | Emphasize the systematicness of methods and pay attention to the teaching of mathematical modeling methods with relatively universal adaptability |
| | | B14 | Elaborate mathematical modeling questions to enhance students' interest in learning |
| | | B15 | Encourage students to participate in modeling competitions |
| | **C Student** | C1 | Broaden the vision of mathematical modeling learning |
| | | C2 | Understand mathematical modeling in many ways |
| | | C3 | Consolidate their own mathematics learning foundation |
| | | C4 | Apply information technology and improve the ability of model solving |
| | | C5 | Experience the complete modeling process and develop mathematical modeling literacy |
| | | C6 | Clarify the difference between mathematical modeling and application problems |
| | | C7 | Pay attention to statistical probability knowledge and improve subjective initiative |
| | | C8 | Improve the breadth of knowledge and exercise the ability of material analysis |
| | | C9 | Participate in mathematical modeling competition |
| | | C10 | Participate in social practice activities |
| **How to implement it in class** | **D Teacher** | D1 | Choose the common phenomena around students as teaching cases |
| | | D2 | The case explanation focuses on the mathematical modeling process |
| | | D3 | The mathematical methods used to solve problems should not exceed the cognitive level of most students |
| | | D4 | Solving mathematical application problems cannot be regarded as a mathematical modeling process |
| | | D5 | Optimize the situation setting and strengthen the basic idea of the model |
| | | D6 | Introduce new lessons with real situations |
| | | D7 | Start from the problem situation of mathematical concepts, cultivate students' awareness of mathematical application |
| | | D8 | Start with the problem of mathematical research-based learning, cultivate students' mathematical modeling ability |

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|---|---|---|---|
| | | D9 | Pay attention to basic knowledge, return to basic knowledge and apply basic knowledge |
| | | D10 | Select examples and strengthen the guidance of problem situations |
| | | D11 | Provide cognitive scaffolding for students |
| | | D12 | Elaborate manual activities |
| | | D13 | provide students with opportunities for interactive communication |
| | | D14 | Provide targeted feedback for students from the perspective of level evaluation |
| | | D15 | Give full play to the promotion function of after-school exercises |
| | | D16 | Set time limited examination links in class |
| | **E Student** | E1 | Give full play to students' subjectivity |
| | | E2 | Pay attention to integrating theory with practice and improve mathematical modeling quality |
| | | E3 | Combine reading and thinking to deeply explore the essence of the problem |

Pre-service teachers can recognize 12 points, accounting for 22.64%. Among the training strategies proposed by predecessors, 34 points relate to how to implement them in middle school, pre-service teachers can recognize 11 points, accounting for 32.35%, and 19 points relate to how to implement them in class, pre-service teachers can recognize 1 points, accounting for 5.26%.

In the dimension of "how to implement it in middle school", there are 9 implementation strategies for schools. They recognize 2 of them, accounting for 22.22%; There are 15 implementation strategies for teachers, and they recognize 4 of them, accounting for 26.67%; There are 10 implementation strategies for students, and they recognize 5 of them, accounting for 50.00%.

In the dimension of "how to implement it in class", there are 16 implementation strategies for teachers, and they recognize 1 of them, accounting for 6.25%; There are 3 implementation strategies for students. They recognize 0 of them, accounting for 0.00%.

It can be seen that pre-service high school mathematics teachers do not have a wide range of understanding of the implementation of mathematical modeling literacy, and they have not realized more than half of the training strategies put forward by predecessors. Whether from the two dimensions or from the implementation subject of each dimension, their understanding has not reached half. When the implementation subject is the student, although they put forward their own opinions, the training strategies put forward by predecessors do not involve relevant contents, and the feasibility needs to be further explored. At the same time, there is a large gap in their understanding of these two dimensions and the three implementation subjects in the middle school dimension, indicating that their understanding of the implementation strategy is not comprehensive and their suggestions are not perfect. See Table 2 for details.

**Table 2 Cognitive scope**

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| Primary index | Points | Total Points | Secondary index | Points | Total Points |
|---|---|---|---|---|---|
| **How to implement it in middle school** | 11 | 34 | **A School** | 2 | 9 |
| | | | **B Teacher** | 4 | 15 |
| | | | **C Student** | 5 | 10 |
| **How to implement it in class** | 1 | 19 | **D Teacher** | 1 | 16 |
| | | | **E Student** | 0 | 3 |

### 4.2 Cognitive Focus

In the dimension of "how to implement it in middle school", their understanding mainly focuses on "students should find and solve practical problems in real life", accounting for 27.45% of the total number. For the point that "teachers should create situations for students to model", the number of people recognized accounts for 23.53% of the total number. Relatively speaking, these two points are the two points with a large number of people in this dimension, and the number of people who recognize these two points accounts for 50.98% of the total number. It can be seen that pre-service teachers can realize that mathematical modeling should be connected with real life. Teachers play a leading role and provide students with opportunities for mathematical modeling by creating situations. Students can better master relevant knowledge by solving practical problems, deepen their understanding of mathematical modeling and understand the importance of mathematical modeling.

In the dimension of "how to implement it in class", their understanding mainly focuses on "teachers should use practical problems to lead in", the number of people recognized accounts for 25.49% of the total number. For the point that "teachers should strengthen the connection with real life", the number of people recognized accounts for 23.53% of the total number. The implementation subjects of these two points are teachers, and the number of people who recognize these two points accounts for 49.02% of the total number. It can be seen that some pre-service high school mathematics teachers can realize that the significance of mathematical modeling lies in solving practical problems with mathematical knowledge.

It can be seen that the focus of pre-service high school mathematics teachers' understanding of implementing mathematical modeling literacy falls on the need for mathematical modeling to be connected to real life, both inside the secondary school and in the classroom, with a focus on relating to real-world problems. See Table 3 for details.

**Table 3 Pre-service high school mathematics teachers' understanding of training strategies**

| Primary index | Secondary index | Symbol | Viewpoint | Percentage （%） |
|---|---|---|---|---|

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| | | | | |
|---|---|---|---|---|
| **How to implement it in middle school** | **F School** | F1 | Set up courses related to mathematical modeling | 7.84 |
| | | F2 | Organize mathematical modeling competition | 9.80 |
| | **G Teacher** | G1 | Have the awareness of mathematical modeling and realize the importance of mathematical modeling to students | 13.73 |
| | | G2 | Learn mathematical modeling related courses | 1.96 |
| | | G3 | Teach students a variety of mathematical models | 9.80 |
| | | G4 | Guide students to test the established model | 7.84 |
| | | G5 | Create situations and let students model | 23.53 |
| | | G6 | Teach students the steps of mathematical modeling | 3.92 |
| | | G7 | Set up special explanation and training of mathematical modeling | 1.96 |
| | | G8 | Pay attention to the teaching of basic concepts of mathematical modeling | 3.92 |
| | | G9 | Train students' modeling thinking | 1.96 |
| | **H Student** | H1 | Participate in mathematical modeling competition | 11.76 |
| | | H2 | Discover and solve practical problems in real life | 27.45 |
| | | H3 | Participate in comprehensive practical activities | 1.96 |
| | | H4 | Experience the process of modeling | 9.80 |
| | | H5 | Look at some phenomena in life from the perspective of Mathematics | 7.84 |
| | | H6 | Find out the mathematical relationship according to the topic | 1.96 |
| | | H7 | Strengthen the understanding of relevant contents of mathematical modeling | 1.96 |
| | | H8 | Apply information technology and learn to use statistical software | 3.92 |
| **How to implement it in class** | **I Teacher** | I1 | Introduce new lessons with real situations | 25.49 |
| | | I2 | Use mathematical models to consolidate knowledge | 1.96 |
| | | I3 | Implement mathematical modeling literacy from three aspects: teaching objectives, teaching process and teaching evaluation | 5.88 |
| | | I4 | Strengthen the connection with real life | 23.53 |
| | | I5 | Choose representative teaching materials | 1.96 |
| | | I6 | Infiltrate the idea of mathematical modeling | 1.96 |

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| | | I7 | Assign math composition | 3.92 |
| | **J Student** | J1 | Integrate the mathematical knowledge realized in daily life into classroom learning | 1.96 |
| | | J2 | Group cooperation and exchange | 5.88 |

### 4.3 Cognitive Rationality

The statements of master of education are summarized as 28 points, of which 12 points are similar to the previous suggestions, accounting for 42.86%. In the dimension of "how to implement in middle school", their expression is summarized as 19 points, of which 11 points are similar to the previous suggestions, accounting for 57.89%; In the dimension of "how to implement in class", their expression is summarized as 9 points, of which 1 points are similar to the previous suggestions, accounting for 11.11%.

In terms of specific contents, they have focused on the two points that "teachers should create situations for students to model" and "teachers should use practical problems to lead in", which are similar to the previous teaching suggestions. However, "students should find and solve practical problems in real life" and "teachers should strengthen the connection with real life", although a large number of people have recognized, relevant contents have not been mentioned in previous teaching suggestions.

It can be seen that the pre-service high school mathematics teachers' understanding of the implementation of mathematical modeling literacy is not very reasonable. Although they can put forward some suggestions according to the learned professional knowledge and existing professional skills, the suggestions are still one-sided, and some views lack feasibility or effectiveness, which needs to be further explored and considered. See Table 4 for details.

**Table 4 Cognitive validity**

| **Primary index** | **Secondary index** | **Symbol** | **Viewpoint** | **Percentage（%）** |
|---|---|---|---|---|
| **How to implement it in middle school** | **A School** | A1 | Innovate idea | 0.00 |
| | | A2 | Optimize the resource allocation of school mathematical modeling | 0.00 |
| | | A3 | Encourage school-based research on mathematical modeling | 0.00 |
| | | A4 | Develop mathematical modeling cases in teaching materials | 0.00 |
| | | A5 | Create academic environment of mathematical modeling | 0.00 |
| | | A6 | Set up mathematical modeling activity course | 7.84 |
| | | A7 | Improve the evaluation mechanism of mathematical modeling | 0.00 |

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| | | A8 | Organize mathematical modeling activities | 9.80 |
| | | A9 | Strengthen the relevant training of mathematical modeling | 0.00 |
| | **B Teacher** | B1 | Improve the awareness of mathematical modeling | 13.73 |
| | | B2 | Strengthen the learning of modeling software | 0.00 |
| | | B3 | Sort out the appropriate mathematical modeling data | 0.00 |
| | | B4 | Train students' modeling thinking | 1.96 |
| | | B5 | Encourage students to enter life and cultivate the vision of "discovering mathematics" | 0.00 |
| | | B6 | Design the modeling of some open problems | 23.53 |
| | | B7 | Cultivate students' model building ability | 0.00 |
| | | B8 | Take the modeling problem of design mathematics as the teaching countermeasure | 0.00 |
| | | B9 | Focus on key steps of modeling | 3.92 |
| | | B10 | Improve the evaluation and examination mechanism | 0.00 |
| | | B11 | Pay attention to the help of modeling to mathematical knowledge | 0.00 |
| | | B12 | Help students summarize the basic models of mathematical modeling and form the systematicness of knowledge | 0.00 |
| | | B13 | Emphasize the systematicness of methods and pay attention to the teaching of mathematical modeling methods with relatively universal adaptability | 0.00 |
| | | B14 | Elaborate mathematical modeling questions to enhance students' interest in learning | 0.00 |
| | | B15 | Encourage students to participate in modeling competitions | 0.00 |
| | **C Student** | C1 | Broaden the vision of mathematical modeling learning | 0.00 |
| | | C2 | Understand mathematical modeling in many ways | 1.96 |
| | | C3 | Consolidate their own mathematics learning foundation | 0.00 |
| | | C4 | Apply information technology and improve the ability of model solving | 3.92 |

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| | | C5 | Experience the complete modeling process and develop mathematical modeling literacy | 9.80 |
| | | C6 | Clarify the difference between mathematical modeling and application problems | 0.00 |
| | | C7 | Pay attention to statistical probability knowledge and improve subjective initiative | 0.00 |
| | | C8 | Improve the breadth of knowledge and exercise the ability of material analysis | 0.00 |
| | | C9 | Participate in mathematical modeling competition | 11.76 |
| | | C10 | Participate in social practice activities | 1.96 |
| **How to implement it in class** | **D Teacher** | D1 | Choose the common phenomena around students as teaching cases | 0.00 |
| | | D2 | The case explanation focuses on the mathematical modeling process | 0.00 |
| | | D3 | The mathematical methods used to solve problems should not exceed the cognitive level of most students | 0.00 |
| | | D4 | Solving mathematical application problems cannot be regarded as a mathematical modeling process | 0.00 |
| | | D5 | Optimize the situation setting and strengthen the basic idea of the model | 0.00 |
| | | D6 | Introduce new lessons with real situations | 25.49 |
| | | D7 | Start from the problem situation of mathematical concepts, cultivate students' awareness of mathematical application | 0.00 |
| | | D8 | Start with the problem of mathematical research-based learning, cultivate students' mathematical modeling ability | 0.00 |
| | | D9 | Pay attention to basic knowledge, return to basic knowledge and apply basic knowledge | 0.00 |
| | | D10 | Select examples and strengthen the guidance of problem situations | 0.00 |
| | | D11 | Provide cognitive scaffolding for students | 0.00 |
| | | D12 | Elaborate manual activities | 0.00 |
| | | D13 | provide students with opportunities for interactive communication | 0.00 |
| | | D14 | Provide targeted feedback for students from the perspective of level evaluation | 0.00 |

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| | | D15 | Give full play to the promotion function of after-school exercises | 0.00 |
| | | D16 | Set time limited examination links in class | 0.00 |
| | **E Student** | E1 | Give full play to students' subjectivity | 0.00 |
| | | E2 | Pay attention to integrating theory with practice and improve mathematical modeling quality | 0.00 |
| | | E3 | Combine reading and thinking to deeply explore the essence of the problem | 0.00 |

## 5. DISCUSSION

### 5.1 Cognitive Scope

From the above statistics, it can be seen that the current pre-service high school mathematics teachers do not have a wide range of understanding of the implementation of mathematical modeling literacy, and they have not realized more than half of the training strategies put forward by predecessors. Whether from the two dimensions or from the implementation subject of each dimension, their understanding has not reached half. When the implementation subject is the student, although they put forward their own opinions, the training strategies put forward by predecessors do not involve relevant contents, and the feasibility needs to be further explored. At the same time, there is a large gap in their understanding of these two dimensions and the three implementation subjects in the middle school dimension, indicating that their understanding of the implementation strategy is not comprehensive and their suggestions are not perfect. Therefore, the current pre-service high school mathematics teachers' cognition of implementing mathematical modeling literacy is not comprehensive. This is also consistent with some previous research results. Sun finds that teachers' teaching is the main factor affecting students' mathematical modeling literacy. At present, the main problems are: Teachers' understanding of mathematical modeling is biased; Teachers are lack of knowledge reserves and resources in mathematical modeling.

### 5.2 Cognitive Focus

From the above statistics, it can be seen that the current pre-service teachers can realize that mathematical modeling should be connected with real life. Teachers play a leading role and provide students with opportunities for mathematical modeling by creating situations. Students can better master relevant knowledge by solving practical problems, deepen their understanding of mathematical modeling and understand the importance of mathematical modeling. Therefore, the focus of pre-service high school mathematics teachers' understanding of implementing mathematical modeling literacy falls on the need for mathematical modeling to be connected to real life, both inside the secondary school and in the classroom, with a focus on relating to real-world problems.

### 5.3 Cognitive Rationality

From the above statistics, it can be seen that the current pre-service high school mathematics teachers' understanding of the implementation of mathematical modeling literacy is not very reasonable. Although they can put forward some suggestions according to their learned professional knowledge and existing professional skills, the suggestions still have some aspects,

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and some views are lack of feasibility or effectiveness, which needs to be further explored and considered. Therefore, the current pre-service high school mathematics teachers' cognition of implementing mathematical modeling literacy is not very reasonable. Some previous research results also involve this point of view. Tang finds that the main reasons for the current low literacy of high school students in mathematical modeling are teachers' lack of overall grasp and in-depth research on the design of mathematical modeling teaching contents in textbooks, teachers' less clear teaching objectives and learning goals for each stage of mathematical modeling, and teachers' low comprehensive literacy.

## 6. CONCLUSION

Studies have shown that teachers' perceptions of implementing mathematical modeling literacy directly affect the formation of students' mathematical modeling literacy. The current level of mathematical modeling literacy among high school students is generally low, so is it that teachers' perceptions of how to implement mathematical modeling literacy are not comprehensive? Is it not reasonable? For this reason, this study investigates pre-service high school mathematics teachers' perceptions about the implementation of mathematical modeling literacy. Through the survey and analysis, it is evident that the current pre-service high school mathematics teachers' awareness of implementing mathematical modeling literacy is not extensive, and they are not aware of more than half of the development strategies proposed by previous authors. Whether from two dimensions or from the main body of each dimension implemented, their awareness is also not up to half; the current pre-service high school mathematics teachers' awareness of implementing mathematical modeling literacy is not very reasonable and still exists somewhat one-sided, and some of the ideas proposed lack feasibility or validity, which needs to be further explored and considered.

Therefore, we suggest that: 1. Train experts and teachers of pre-service high school mathematics teachers, provide them with more teaching practice opportunities, and hold group meetings to discuss how to implement mathematical modeling literacy; 2. Pre-service high school mathematics teachers should seize the opportunity of teaching practice, pay attention to observing students' learning state in the process of practice, reflect on whether the training strategy proposed by the summary is reasonable, and then further adjust and explore according to the actual situation of the school and classroom.

Finally, this study selects 51 masters of mathematics education in the same grade in the same university and lacks other types of participants. Therefore, future research should expand the sample range and adopt a variety of research methods to further investigate the mathematical modeling literacy of pre-service high school mathematics teachers, in order to find more detailed conclusions and suggestions.

**Founding**

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**Competing Interests**

The authors declare that they have no competing interests.

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