Original Research Article

Pre-service Mathematics Teachers' Cognition of "Senior High School Students can Understand Knowledge but cannot Solve Problems".

Abstract: In senior high school mathematics teaching, many students can understand the knowledge but cannot solve the problems. Existing studies mainly focus on front-line teaching, but no one has explored the cognition of pre-service mathematics teachers to this phenomenon. Whether pre-service mathematics teachers have clear cognition of this phenomenon will greatly affect the quality of mathematics teaching in senior high school in the future. As for the selection of sampling techniques, random sampling was used in this paper, and a total of 30 graduate students and undergraduates from the School of Mathematics and Statistics of Shandong Normal University who want to be senior high school mathematics teachers in the future are selected as the survey objects. As for the selection of investigation method, interview method was used to investigate their understanding of this phenomenon in this paper. The results are as follows: In terms of causes, 93. 33% pre-service mathematics teachers believed that students' grasp of knowledge is not enough, 56. 67% believed that students' thinking is narrow and limited, etc; In terms of countermeasures, 56. 67% believed that students' ability to use knowledge is not enough, and 30% believed that teachers should pay attention to the inspiration of students' ideas and methods, etc. The conclusions of this paper are as follows: (1) For the phenomenon that senior high school students can understand the knowledge but cannot solve the problem, most pre-service mathematics teachers' cognition have shortcomings in both rationality and comprehensiveness. (2) It is necessary to train pre-service mathematics teachers.

Keywords: Senior High School Mathematics, Pre-service Teachers, Problem-solving, Cognition, Cultivation Suggestion

1. Introduction

Ordinary High School Mathematics Curriculum Standards(2017 Edition, 2020 Revision) (Formulated by the Ministry of Education of the People's Republic of China, 2020) points out that the academic quality is the basis of the corresponding examination proposition. Whether it is high school graduation examination, college entrance examination

or college independent admission examination, it is inseparable from the form of examination questions to examine students. Under the new curriculum background, the goal of mathematics teaching in senior high school is no longer just to impart knowledge, but more importantly to cultivate students' problem-solving ability. However, in the current senior high school mathematics teaching, students' problem-solving ability is generally inadequate(Tang, 2024). At present, many scholars have found in front-line teaching that many senior high school students can understand mathematics knowledge, but cannot solve problems independently(Dai, 2019; Kan, 2014). This phenomenon not only frustrated students' self-confidence, affected students' learning, but also adversely affected teachers' teaching. Most of the current studies are from the perspective of front-line teaching. However, no one explored the cognition of pre-service mathematics teachers to this phenomenon. Pre-service teachers are an important reserve force of teachers(Guo, 2025). Whether their cognition of this phenomenon is accurate will greatly affect the quality of mathematics teaching in senior high schools in the future. Therefore, it is necessary to study pre-service mathematics teachers' cognition of “senior high school students can understand knowledge but cannot solve problems”.

2. Literature Review

It is a common phenomenon of mathematics teaching that senior high school students can understand the knowledge but cannot solve the problems Many scholars have done research on this phenomenon, and the existing research mainly focuses on the causes and countermeasures.

In terms of causes, Huang et al.(2024) believed that students' poor grasp of basic knowledge is one of the causes why they cannot solve the problems. Yang et al.(2024) believed that students' narrow thinking and limited thinking lead to difficulties in understanding mathematical problems. Zhu et al.(2023) believed that senior high school students often give wrong answers to mathematics problems because of their inadequate ability to examine and understand the questions. Liang, & Zhang et al.(2024) believed that many senior high school mathematics teachers still choose a very traditional and simple teaching method for teaching. Yan et al.(2024) believe that whether teachers have a high level of professional quality is very important to improve students' problem-solving ability.

In terms of countermeasures, Meng et al.(2024) believed that teachers should pay attention to the teaching of mathematical thoughts. Li et al.(2024) believed that teachers should pay attention to the teaching of multiple solutions to one problem. Liang et al.(2024) believed that teachers should pay attention to imparting basic knowledge. Liang et al.(2023) believed that teachers need to encourage and give students some time to summarize and reflect. Yang et al.(2024) believed that teachers should make students

pay attention to mistakes. Yang et al.(2024) believe that teachers should pay attention to the teaching of problem-solving steps, methods and skills.

After reading relevant articles, it can be found that there are many causes and countermeasures for students' inability to solve problems. The following causes have been mentioned more often in previous studies: (1) Students' grasp of basic knowledge is not in place; (2) Students' thinking is narrow and limited; (3) Students' ability to examine and understand the problem is insufficient; (4) Many senior high school mathematics teachers have outdated teaching methods; (5) Many senior high school mathematics teachers lack professional quality.

The following countermeasures are often mentioned in previous studies: (1) Teachers should pay attention to the teaching of mathematical thoughts; (2) Teachers should pay attention to the teaching of multiple solutions to one problem; (3) Teachers should focus on teaching basic knowledge; (4) Teachers should let students pay attention to reflection and summary; (5) Teachers should draw students' attention to mistakes; (6) Teachers should pay attention to the steps, methods and skills of problem solving.

As can be seen from the above research, although there have been many researches on the phenomenon that senior high school students cannot solve mathematics problems, most of them are thought and summarized from the perspective of front-line teaching, which are some experiences gradually discovered and summarized by teachers after they enter the job. So far, no one has explored the causes and countermeasures for this phenomenon from the perspective of pre-service mathematics teachers (referring to undergraduate mathematics teachers and graduate students in mathematics education who will be engaged in the teaching profession).

Teachers are the inheritors and disseminators of knowledge, the developers of students' intelligence and the shapers of their personalities, and the “engineers of the soul”. In the process of education, teachers are the educators, leaders and organizers of students' physical and mental development. If mathematics teachers can clearly realize the causes and countermeasures that senior high school students can understand knowledge but cannot solve mathematical problems before taking office, they can timely deal with such problems after entering the office. This can not only reflect the professional quality of teachers, but also help students to learn mathematics. Therefore, it is very necessary to study whether pre-service mathematics teachers can correctly realize the phenomenon that senior high school students can understand knowledge but cannot solve mathematical problems, so that they can improve their teaching skills and professional quality as much as possible before entering the job.

This paper aims to explore the problems existing in the training of pre-service mathematics teachers by investigating their cognition of the phenomenon of “students can understand knowledge but canot solve problems”, and provide solutions to this problem

from the perspective of pre-service mathematics teacher training for the reference of educators.

The main research questions of this paper are:

(1) For the phenomenon that senior high school students can understand knowledge but cannot solve problems, what is the comprehensiveness and rationality of pre-service mathematics teachers' cognition of its causes?

(2) For the phenomenon that senior high school students can understand knowledge but cannot solve problems, what is the comprehensiveness and rationality of pre-service mathematics teachers' cognition of its countermeasures?

3. Research Method

3. 1 Samples

The education of normal university students is the starting point of teacher training and the key link to determine the quality of teachers and the level of education development in the future(Chen, 2024). The method of random sampling was adopted in this study. In this study, a total of 30 students were selected from the graduate students majoring in subject teaching (mathematics) and the undergraduate students majoring in mathematics and applied mathematics in the School of Mathematics and Statistics of Shandong Normal University who wanted to become senior high school teachers in the future.

3. 2 Investigation method

Interview method can obtain direct and reliable information and materials, easily provide in-depth and detailed information, and is not limited by written language. Combined with the research questions and contents, this study adopts the interview method to conduct the investigation, and the interview outline is designed as follows:

(1) In your senior high school mathematics study, have you ever encountered the phenomenon that you can understand the knowledge but cannot solve the problem?

(2)What do you think are the causes for this phenomenon?

(3)What do you think are the countermeasures for this phenomenon?

The interview questions can directly reflect the pre-service mathematics teachers' cognition of the phenomenon, which is convenient for further investigation and research.

3. 3 Data collection

In order to make the collected information more reliable and credible, structured interview method was used in this study, and the author interviewed all the survey subjects one by one. The interview contents were recorded in the whole process with the permission of the survey subjects, and sorted out one by one after the interview.

3. 4 Content Processing

The first step is to transcribe all the interview recordings of the survey subjects into text materials, and arrange them in strict accordance with the original words during the transcription process. These texts are then encoded, with letters representing their meanings, and those with similar meanings are grouped together. For example, the letter A stands for “students' insufficient grasp of knowledge”, so that similar ideas such as “students' incomplete grasp of knowledge” and “students' insufficient understanding of knowledge” can be expressed by the letter A. Then, the percentage of the occurrence was calculated to obtain the understanding of the causes and countermeasures for the phenomenon of pre-service mathematics teachers.

The second step is to compare the contents of the survey with previous studies. If the meaning expressed in the survey result is the same or similar to that expressed in the previous studies, it is considered that the survey object is aware of this view; otherwise, it is considered that the survey object is not aware of this view. Count how many times each item is mentioned and make a statistical table for analysis.

The third step is to analyze the answers of pre-service mathematics teachers and explore the comprehensiveness and rationality of pre-service mathematics teachers' views.

4. Result Analysis

4. 1 Preservice mathematics teachers' cognition of the causes for this phenomenon

According to the survey, 93. 33% of pre-service mathematics teachers think that students' grasp of knowledge is not enough, 56. 67% think that students' ability to use knowledge is not enough”, 43. 33% think that students lack training, 36. 67% think that students have problems in learning methods. 3. 33% think that students do not understand their own problems, 23. 33% think that mathematics problems are difficult, 26. 67% think that teachers do not emphasize the method of solving problems. The details are shown in Table 1.

Table 1

Preservice mathematics teachers' understanding of the causes

Aspect	Implication	Percent
Students	Students' grasp of knowledge is not enough	93. 33
	Students' ability to use knowledge is not enough	56. 67
	Students lack training	43. 33
	Students have problems in learning methods	36. 67
	Students do not understand their own problems	3. 33
Mathematical problems	Mathematics problems are difficult	23. 33
Teachers	Teachers do not emphasize the method of solving problems	26. 67

Compared to the causes mentioned in literature review, 93. 33% of pre-service mathematics teachers could realize that students' grasp of basic knowledge is not in place, 56. 67% could realize that students' thinking is narrow and limited. Other points of view are not recognized by most pre-service mathematics teachers. The details are shown in Table 2.

Table 2

Comparison of causes

The causes mentioned in the literature review	Percent
Students' grasp of basic knowledge is not in place.	93. 33
Students' thinking is narrow and limited.	56. 67
Students' ability to examine and understand the problem is insufficient.	0
Many senior high school mathematics teachers have outdated teaching methods.	0
Many senior high school mathematics teachers lack professional quality.	0

4. 2 Preservice mathematics teachers' cognition of the countermeasures of this phenomenon

The survey found that 73. 33% of pre-service mathematics teachers believed that students should increase the amount of practice, 56. 67% believed that students should reflect and summarize in time, 33. 33% believed that students should listen carefully in class, 16. 67% believed that students should preview before class, 13. 33% believed that students should communicate more with teachers and classmates. 6. 67% think that students should think independently, 3. 33% think that students should carefully examine the questions, 30% think that teachers should pay attention to the inspiration of students' thoughts and methods, 20% think that teachers should pay attention to the teaching of typical examples, 6. 67% think that teachers should give students enough time in class. 3. 33% think that teachers should pay attention to variable practice. The details are shown in Table 3.

Table 3

Preservice mathematics teachers' understanding of the countermeasures

Aspect	Implication	Percent
Students	Students should increase the amount of practice.	73. 33
	Students should reflect and summarize in time.	56. 67
	Students should listen carefully in class.	33. 33
	Students should preview before class.	16. 67
	Students should communicate more with teachers and classmates.	13. 33
Teachers	Students should think independently.	6. 67
	Students should carefully examine the questions.	3. 33
	Teachers should pay attention to the inspiration of students' thoughts and methods.	30. 00
	Teachers should pay attention to the teaching of typical examples.	20. 00
	Teachers should give students enough time in class.	6. 67
	Teachers should pay attention to variable practice.	3. 33

Compared to the countermeasures mentioned in literature review, 56. 67% of pre-service mathematics teachers could realize that teachers should let students pay attention to reflection and summary, 30% could realize that teachers should pay attention to the teaching of mathematical thoughts. , 20% could realize that teachers should pay attention to the teaching of multiple solutions to one problem". Other points of view are not recognized by most pre-service mathematics teachers. The details are shown in Table 4.

Table 4

Comparison of countermeasures

The countermeasures mentioned in the literature review	Percent
Teachers should pay attention to the teaching of mathematical thoughts.	30. 00
Teachers should pay attention to the teaching of multiple solutions to one problem	20. 00
Teachers should focus on teaching basic knowledge	0
Teachers should let students pay attention to reflection and summary.	56. 67
Teachers should draw students' attention to mistakes.	0
Teachers should pay attention to the steps, methods and skills of problem solving	0

5. Result Discussion

The following will discuss the cognition of pre-service mathematics teachers from the perspectives of comprehensiveness and rationality.

5. 1 The discussion for the causes

The following will be discussed from two aspects: comprehensiveness and rationality.

5. 1. 1 Comprehensiveness

The view “students' grasp of basic knowledge is not in place” mentioned in literature review is highly consistent with the view “students' grasp of knowledge is not enough” in interview results, which is also the most mentioned cause by pre-service mathematics teachers, accounting for 93. 33%. In this regard, the vast majority of pre-service mathematics teachers have a good cognition. The view “students' thinking is narrow and limited” mentioned in literature review is similar to the view “students' ability to use knowledge is not enough” in interview results, and 56. 67% of pre-service mathematics teachers were aware of this. However, the view “students' ability to examine and understand the problem is insufficient”, “many senior high school mathematics teachers

have outdated teaching methods", and "many senior high school mathematics teachers lack professional quality" mentioned in literature review were not reflected in the interview materials. That is to say, basically all pre-service mathematics teachers were not aware of these points.

For the "Students' grasp of basic knowledge is not in place" and "Students' thinking is narrow and limited" mentioned in the literature review, most pre-service mathematics teachers can have a relatively clear cognition. However, For the "students' ability to examine and understand the problem is insufficient", "many senior high school mathematics teachers have outdated teaching methods" and "many senior high school mathematics teachers lack professional quality" mentioned in the literature review, most pre-service mathematics teachers cannot have a relatively clear cognition.

As for students' problem-solving ability, Meng(2024) believed that problem solving ability training is an important part of mathematics teaching in senior high school, which is crucial to students' success in mathematics learning and other fields. Mathematics has a high degree of abstraction and logical rigor. Only with enough ability of examining and reading questions can we clarify the known conditions, the results to be obtained and the hidden information in the questions. If teachers ignore the cultivation of students' ability of examining questions in the course of teaching, it will not help students to solve problems independently. Teaching with a single teaching method may lead to boredom in the classroom, which is not conducive to students' independent problem-solving(Liang, &Zhang, 2024). The use of various teaching methods by teachers can better meet the needs of different students, enhance the enthusiasm of students in learning, and improve the teaching effect, such as inquiry learning and cooperative learning. In *the Opinions on Carrying Forward the Spirit of Educators and Strengthening the Construction of High-quality Professional Teachers in the New Era*, the State Council clearly proposes to improve teachers' professional quality, improve teachers' discipline ability and discipline accomplishment, and enhance teachers' teaching and educating ability. A highly professional teacher can obviously have a more professional way of dealing with students who can understand knowledge but cannot solve mathematics problems.

5. 1. 2 Rationality

In addition to the above, some pre-service mathematics teachers also put forward some other views on the causes:

Some pre-service mathematics teachers believed that the current mathematics problems are very difficult, which is reflected in the various types of questions, high flexibility, strong comprehensiveness, etc. The new college entrance examination focuses on students' thinking and ability, and pays attention to the achievement of students' core literacy in mathematics. Therefore, the difficulty of mathematics problems will indeed be higher than before.

93. 33% pre-service mathematics teachers think that the students do not practice enough. That is to say, almost all pre-service mathematics teachers advocated the so-called "question sea tactics". This view is obviously unreasonable.

Firstly, "question sea tactics" may not be able to achieve the ideal effect. "Question sea tactics" limits students' thinking, makes it difficult for students to flexibly use the knowledge to solve problems, and ultimately affects the improvement of students' problem-solving ability(Meng, 2024). The number of questions in the new college entrance examination in 2024 has been reduced, and the comprehensions have been further increased. The last multiple-choice question is an innovative comprehensive examination of the properties of functions and plane analytic geometry, which does not belong to any graph (line, circle, ellipse, hyperbola, parabola, etc.) that students have learned. A new definition of fractional series is given, and a comprehensive investigation is carried out in combination with the knowledge of probability and counting principle. The examination of conic curve in the solution question is placed in the position of 16 questions, and it's less difficult than before. All these changes show that the college entrance examination pays more and more attention to the investigation of students' mathematical thinking and mathematical ability, and pays more attention to the achievement of students' mathematical core accomplishment. In the so-called "question sea tactics" in a large number of exercises will inevitably have a lot of repetitive and homogeneous content, which is easy to solidify students' thinking, the formation of a thinking set, which is not conducive to the cultivation of students' creative thinking and thinking divergence, it is difficult for students to play their own strength in the new college entrance examination situation.

Secondly, “question sea tactics” itself has drawbacks that can not be ignored. Cheng(2024) believed that the “question sea tactics” will cause students' anxiety, wear down students' patience and inhibit students' creativity. A lot of exercises are bound to take up a lot of time for students and teachers. Students have to spend a lot of time to solve the problems, teachers also have to spend a lot of time to explain the problems, which will undoubtedly increase the teacher's teaching pressure and students' learning pressure. Students immersed in the “question sea tactics” for a long time may feel tired, leading to a decline in interest in learning, and then affect the enthusiasm and initiative of learning. We cannot deny that with the increase of the amount of practice, students' mastery of knowledge will be improved, but to solve the phenomenon of “can understand knowledge but cannot solve problems” by “question sea tactics” is not feasible.

Some pre-service mathematics teachers also mentioned problems with students' learning methods. As mentioned in the teaching suggestions of *Ordinary High School Mathematics Curriculum Standards(2017 Edition, 2020 Revision)* (Formulated by the Ministry of Education of the People's Republic of China, 2020), “In teaching practice, we should constantly explore and innovate teaching methods, pay attention not only to how to teach, but also to how to learn, guide students to learn mathematics and develop good learning habits. “In other words, the problem of students' learning is essentially the problem of teachers' teaching. Mathematics teaching method and learning method are not two separate individuals, but an interrelated and interactive whole, it can even be said that mathematics teaching method is mathematics learning method(Xu, & Yu, 2024). Therefore, the idea that there is something wrong with students' learning methods is not profound enough.

5. 2 The discussion for the countermeasures

The following will be discussed from two aspects: comprehensiveness and rationality.

5. 2. 1 Comprehensiveness

The view of “teachers should let students pay attention to reflection and summary” mentioned in literature review is relatively consistent with the “students should reflect and summary in time” in the interview materials, and 56. 67% of pre-service mathematics teachers can realize this point. The view of “teachers should pay attention to the

teaching of mathematical thoughts" mentioned in literature review is relatively consistent with the "teachers should pay attention to the inspiration of students' thoughts and methods" in interview materials, but only 30% of pre-service mathematics teachers can realize this point. The view of "teachers should pay attention to the teaching of multiple solutions of one problem" mentioned in literature review is relatively consistent with the "teachers should pay attention to the teaching of typical examples" in the interview materials, but only 20% of pre-service mathematics teachers can realize this point. A total of six countermeasures were mentioned in the literature review, and pre-service mathematics teachers could recognize three of them, but the proportion was not high. The other three countermeasures were not mentioned by the pre-service mathematics teachers.

Mathematical thoughts and methods refer to the basic concepts, principles and ideas adopted in solving mathematical problems, which can help us understand and explore the structure of mathematical problems and point out the direction of solving problems. Li(2024) believes that teachers need to strengthen the penetration of mathematical thoughts to help students correctly understand mathematics and effectively solve problems.

The teaching of multiple solutions to one problem should be valued. Li(2024) believed that teachers should encourage students to form a group to jointly explore multiple solutions to the topic, so as to integrate the thinking of different students and break the thinking stereotype. Teachers should design multi-solution questions to stimulate students' interest, train their ability to solve math problems, inspire students to think about problems from different angles, and find the best way to solve problems(Li, 2024).

5. 2. 2 Rationality

In addition, some pre-service mathematics teachers also put forward some other views in terms of countermeasures:

As for the "students should increase the amount of practice" point of view, as mentioned above, "question sea tactics" will not work. Some pre-service mathematics teachers put forward the views of "students should preview before class", "students should listen carefully in class" and "students should communicate more with teachers and classmates", etc. Guo(2023) believed that in teaching, teachers should reflect on the content of textbooks, students' learning situation, teaching process and other contents, so as to

timely adjust teaching strategies according to the generation of classes, improving the effectiveness of teaching. However, under the constraint of exam-oriented education, most teachers focus their time and energy on knowledge teaching, examination paper commentary, homework correction and solution research, ignoring the value of reflection in teaching, which affects the improvement of teaching level.

5. 3 Brief summary

From the above research, we can draw the following conclusions:

(1) For the causes that senior high school students can understand knowledge but cannot solve mathematics problems, the cognition of most pre-service mathematics teachers is insufficient in comprehensiveness and rationality.

(2) For the countermeasures that senior high school students can understand knowledge but cannot solve mathematics problems, the cognition of most pre-service mathematics teachers is insufficient in comprehensiveness and rationality.

Therefore, it is urgent to improve the professional quality of pre-service mathematics teachers.

6. Conclusion

Senior high school students often have the phenomenon that they can understand knowledge but cannot to solve problems in mathematics learning. Many scholars have done a lot of research on this phenomenon, and given causes and countermeasures. This paper takes them as a reference to study the pre-service mathematics teachers' cognition of “senior high school students can understand knowledge but cannot solve problems”. To this end, this paper adopted random sampling method. A total of 30 graduate and undergraduate students in the School of Mathematics and Statistics of Shandong Normal University were selected for interview, who want to be a senior high school mathematics teacher in the future. After investigation, the results are as follows: the causes “students' grasp of basic knowledge is not in place” and “students' thinking is narrow and limited” were realized by most pre-service mathematics teachers; the causes “students' ability to examine and understand the problem is insufficient”, “many senior high school mathematics teachers have outdated teaching methods” and “many senior high school mathematics teachers lack professional quality” were not realized by most pre-

service mathematics teachers; the countermeasures “teachers should let students pay attention to reflection and summary”, “teachers should pay attention to the teaching of mathematical ideas”, and “teachers should pay attention to the teaching of multiple solutions to one problem” were realized by some pre-service mathematics teachers; the countermeasures “teachers should focus on teaching basic knowledge”, “teachers should draw students' attention to mistakes”, and “teachers should pay attention to the steps, methods and skills of problem solving” were not realized by most pre-service mathematics teachers. The majority of pre-service mathematics teachers have insufficient cognition of the comprehensiveness and rationality of this phenomenon. The research object of this survey is 30 education masters and undergraduates, and the sample distribution is concentrated in one university, and the sample size is not large. In the future, it is necessary to increase the number and scope of samples, ensure the objectivity and universality of investigation and analysis, and better help front-line teachers to solve problems in teaching.

Teaching ability is the core ability of normal university students for their future career development. As the backbone of basic education in the future, normal university students' teaching ability will affect the teaching level of basic education (Zhao, Lu, &Zhou, 2024). In order to improve the professional quality of pre-service mathematics teachers and build an excellent teacher team, based on the above findings, this paper gives some suggestions on the training of pre-service mathematics teachers:

(1) In the course of teaching should pay attention to the teaching of mathematical thoughts.

Teachers should pay more attention to the teaching of mathematical thoughts when they talk about the topic. After the implementation of the new curriculum standards, more emphasis is placed on the achievement of students' core literacy in mathematics, and the so-called core literacy refers to the essential character and key ability that students should have to meet the needs of lifelong development and social development. Mathematical thought can effectively improve students' mathematical ability and cultivate the quality of thinking, which is the key to improve students' core accomplishment. Students can understand knowledge but cannot solve mathematics problems. It is very likely that the teacher in the course of teaching the topic did not fully emphasize the mathematical thoughts, nor deliberately train the students' mathematical thoughts.

(2)In the teaching of exercises, we should pay attention to the demonstration and summary of problem solving steps.

When teaching, teachers should pay more attention to the demonstration and summary of problem solving steps. Many students can understand the topics taught by the teacher in class and know what to do, but they still have problems when they do the questions independently. It is very likely that the teacher did not emphasize the method summary in place. Therefore, in the teaching of examples and exercises, teachers must pay attention to showing the steps of solving problems, and summarizing in time, which can help students form a good cognitive structure.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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