The Effective Application of Metacognitive Strategies in High School Mathematics Teaching

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Abstract. Metacognitive strategies, as an educational method that focuses on the metacognitive knowledge and skills of learners' thinking and learning process, have attracted widespread attention in the field of high school mathematics teaching in recent years. This article aims to analyze the effective application of metacognitive strategies in high school mathematics teaching, and deeply explore their role in improving students' mathematical learning achievements and developing mathematical thinking abilities. Firstly, this article provides an overview of the current situation and problems in high school mathematics teaching, including the difficulty of teachers' teaching concepts keeping up with the times, the lack of novelty in teaching methods, and the solidification of students' thinking. Then, the article pointed out the importance of metacognitive strategies for mathematical learning and introduced the basic overview and classification of metacognitive strategies. Next, this article explores in detail how metacognitive strategies can be applied to high school mathematics teaching, including carefully preparing teaching based on metacognition and finding the best teaching methods, guiding students to reflect through metacognitive monitoring, and improving teaching evaluation systems based on metacognition. The effective application of these strategies helps students better understand mathematical concepts, improve problem-solving abilities, and enhance mathematical confidence.

Keywords: Metacognitive strategies; High school mathematics; Effective application.

1. Introduction

In daily lives, mathematics plays its role everywhere, especially with the development and progress of technology, the role of mathematics is becoming increasingly prominent. Mathematics is a challenging discipline that requires students not only to have good computational abilities, but also to develop abstract thinking, logical reasoning, and problem-solving abilities. High school mathematics education aims to provide students with a solid mathematical foundation and lay a solid foundation for their future academic and professional careers. Currently, many educators and students face a common challenge, which is how to teach and learn mathematics more effectively to ensure that students not only pass exams but also have a deep understanding and application of mathematical concepts. In this era of advanced information, educators not only need to pay attention to teaching content but also to teaching methods and strategies. Metacognitive strategies, as a promising teaching method, have attracted widespread interest in mathematics education. Metacognitive strategies emphasize students' understanding of their learning process and how they monitor, adjust, and improve their learning methods. This strategy not only helps to improve students' academic performance but also cultivates their metacognitive awareness, making them more autonomous and effective learners. This article aims to review existing literature and analyze how to effectively apply metacognitive strategies in high school mathematics teaching, providing more effective teaching methods for high school mathematics teaching, and improving the efficiency of high school mathematics teaching.

2. The Current Situation and Problems of High School Mathematics Teaching

2.1. The Current Situation and Problems of High School Mathematics Teaching

The teaching philosophy has a significant impact on the quality and effectiveness of education. It not only guides the practice of educators but also affects students' learning and development. After the new curriculum reform, many teaching concepts have been updated, and subject teaching urgently needs to keep up with the times. Teachers need to immediately update their teaching concepts to adapt to the new educational trends, improve teaching quality, and enhance the actual effectiveness of education. However, in actual teaching, many teachers are still constrained by traditional teaching concepts, focusing mainly on teaching mathematical knowledge and exam-oriented skills, resulting in students not achieving teaching goals such as cognition, skills, emotions, behavior, and social interaction in mathematical learning. Li Na mentioned that traditional teaching concepts do not fully enjoy the "benefits" brought by subject integration, and mathematics learning cannot integrate with the theoretical essence of other subjects, it is always in a state of "fighting alone", resulting in insufficient comprehensive research on students' learning situations by teachers, and the design of teaching plans also deviates from students' learning needs [1]. Teachers' teaching philosophy that does not keep up with the times can lead to a decrease in the actual effectiveness of teaching and cannot meet the needs of students, ultimately leading to students losing competitiveness. Therefore, teachers should constantly reflect and update their teaching philosophy to ensure that their teaching philosophy keeps up with the times and improves the actual effectiveness of education.

2.2. Lack of Novelty in Teaching Methods

In the current educational environment, the teaching goal of teachers is to cultivate talents with comprehensive abilities such as innovative thinking, teamwork, and critical thinking. Traditional exam-oriented education models are no longer able to meet these needs. Therefore, teachers need to actively explore innovative teaching methods to cultivate students' innovative spirit and practical abilities. However, in the actual teaching process, most teachers still use traditional teaching methods, believing that there is no need to deeply understand the origin of concepts and formulas, and only require students to brush through the questions more and memorize different types of questions, resulting in students only knowing how to set a "template" during the problem-solving process and not being clear about the methods and techniques used in the problem-solving process. In the long run, this will lead to dull and uninteresting high school mathematics classroom teaching, reduce students' interest in learning, and fail to stimulate their critical thinking and creativity, making it difficult to achieve teaching objectives under the discipline of literacy. At the same time, some teachers use the same teaching methods for different students, which are not targeted and overlook the diversity of students, leading to some students being ignored or marginalized. Ma Xianli pointed out that only a few teachers can timely update and elevate lesson plans when designing lesson plans, and a large number of teachers only make simple modifications to past math lesson plans, and even directly use them for teaching [2]. Zhai Jingdong believes that due to the influence of traditional education models, there is a relationship between listening and being listened to between teachers and students in the classroom, which does not fully leverage students' subjectivity in the mathematics classroom. There is a lack of efficient communication and exchange between teachers and students, as well as between students and students, and only focuses on one-way transmission of textbook knowledge. This seriously affects the cultivation of students' thinking ability, innovation ability, and application ability [3]. The previous lesson plan design may no longer adapt to modern student needs and learning methods, and continuing to use the previous lesson plan for teaching may result in students not fully understanding or participating in the teaching process, leading to a decrease in student learning effectiveness. Therefore, to meet students' learning requirements and improve their learning outcomes, teachers should actively seek innovative teaching methods.

2.3. Solidification of Students' Thinking

The importance of thinking is self-evident in high school mathematics learning. Especially in high school mathematics, there are many knowledge points involved and the difficulty is relatively high, which requires higher thinking requirements for students. However, the knowledge involved in elementary and middle school mathematics is relatively simple, with low requirements for students' thinking. By simply memorizing, good grades can also be achieved. Therefore, many students and even teachers have not ignored the cultivation of thinking, leading to the solidification of some students' thinking. However, high school learning is difficult and stressful, and many students have no extra time to solve their thinking problems. They can only rely on inertia to cope with subject learning, leading to further rigidity of their thinking and deteriorating learning outcomes. At the same time, the solidification of students' thinking is closely related to teachers' teaching methods. As mentioned earlier, many teachers blindly demand students to memorize by rote, which leads to the lack of development of students' thinking. In addition, Ma Xianli believes that many teachers choose to have very arbitrary standards and purposes in classroom examples, resulting in students being in a passive position and lacking independent thinking and problem-solving processes, which leads to the inability to cultivate students' cognitive abilities, this also leads to a certain degree of solidification of students' thinking when solving problems [2]. The learning of high school mathematics requires high levels of students' thinking, and the solidification of students' thinking is very detrimental to the learning of high school mathematics. Teachers should pay attention to cultivating students' thinking during the teaching process to improve students' learning efficiency.

3. The Necessity of Metacognitive Strategies in High School Mathematics Learning and Teaching

Metacognition refers to an individual's knowledge of their cognitive processes and the ability to regulate these processes. It includes being aware of their learning style, knowing what strategies to use in different situations, and monitoring their learning progress. Mathematical metacognition reveals the control and regulation of students' self-awareness over mathematical learning activities, which helps to develop students' intelligence, unleash their initiative and consciousness in learning, and solve the problem of how students learn scientifically to form good learning habits. Mathematics teachers attach importance to the cultivation of students' metacognitive abilities in teaching practice, which helps to improve classroom teaching efficiency and achieve the goals of middle school mathematics education. Yu Ran pointed out that students with higher levels of mathematical metacognition have higher mathematical problem-solving abilities. The higher a student's level of mathematical metacognition, the richer their metacognitive knowledge, positive metacognitive experience, and good metacognitive monitoring. These factors work together in the process of solving mathematical problems, which will inevitably promote the development of their mathematical problem-solving ability [4]. Meanwhile, Yu also mentioned that students with high levels of mathematical metacognition can keenly identify the mathematical information contained in innovative mathematical problem situations, quickly establish the connection between conditions and problems, and correctly represent problems, they are good at formulating problem-solving plans, and actively reflect, monitor, regulate, and evaluate one's thinking activities and learning outcomes throughout the entire process of solving mathematical problems [4]. Xin Yuechao found that there is a significant positive correlation between mathematical metacognitive strategies and mathematical creative thinking concepts in high school students' mathematics learning [5]. Therefore, in mathematics education, students should focus on the use of mathematical metacognitive strategies, Focus to cultivate students' creative thinking concepts in mathematics.

4. The Application of Metacognitive Strategies in High School Mathematics Teaching

4.1. The Application of Metacognitive Strategies in High School Mathematics Teaching

Based on the connotation of metacognitive strategies, high school mathematics teachers must make sufficient preparations before class. Li Hui proposed that, first of all, under the guidance of metacognitive strategies, high school mathematics teachers must combine the results of metacognitive analysis before designing teaching plans, accurately grasp the actual needs of students, break away from the limitations of "teaching materials", and combine the content of current mathematics textbooks to expand and extend them appropriately, supplementing relevant teaching resources, aiming to meet the learning needs of students. Secondly, under the guidance of metacognitive strategies, high school mathematics teachers should scientifically design mathematics teaching objectives before conducting classroom teaching, so that they cover knowledge objectives, ability objectives, thinking objectives, and emotional objectives [6]. They should pay more attention to high school students' mathematical learning ability, mathematical thinking, development of mathematical thinking, and emotional experiences generated in mathematical learning [6]. At the same time, the survey found that expert teachers should closely grasp the characteristics of students when preparing lessons, combine problems with students' actual situations, and arouse students' interest; When selecting example questions, repeatedly consider which question type is more suitable for students [7]. Under the guidance of metacognitive strategies, teachers should design teaching plans more targeted, such as targeted consolidation exercises targeting weak knowledge points and key and difficult points. Layered teaching is provided for students with different learning backgrounds. For example, when assigning homework, students with a good foundation must complete additional questions, while students with a weaker foundation can complete them with spare time. Gradual teaching promotes students' mastery of knowledge. The example questions selected by teachers should reflect a ladder style and representativeness so that students of different levels can achieve maximum learning outcomes. Develop different learning plans based on the different learning situations of different students in the class. At the same time, high school mathematics teachers consider in advance the problems that students may encounter in mathematics learning when preparing for teaching, and design various solutions.

4.2. Applying Metacognitive Monitoring to Guide Students to Reflect

Confucius said, "I examine myself three times a day." This means that people need to reflect more in their daily lives. Dutch mathematician Friedenthal said, "The only correct way to learn mathematics is to practice creation. Students themselves discover or create what they want to learn." In high school mathematics learning, students need to personally deduce and calculate many concepts, theorems, and formulas to truly understand the mathematical knowledge they have learned and discover its mysteries. Therefore, teachers provide guidance based on metacognitive strategies, are good at guiding students to reflect on the operation process in teaching and stimulate students' enthusiasm for "recreation". At the same time, by reflecting on students, they can understand the shortcomings in their learning process, optimize learning plans, improve learning efficiency, and ultimately achieve maximum learning outcomes. Guo Yufeng and Pan Donghua proposed that in teaching, self-examination and evaluation forms can be designed and developed, allowing students to fill out each unit once [8]. The self-examination form can include whether the learning objectives of the unit are clear, whether there is a learning plan, whether the goals and plans can be adjusted, whether they are interested in the content of the unit, whether they can adjust and maintain a good learning mood, whether they can independently overcome learning difficulties, whether they can ensure preview, listen carefully and review. The ability to understand the teaching content of this unit, allocate learning time reasonably, choose suitable learning methods, have confidence in one's abilities, and be satisfied with one's learning results are also effective methods for cultivating students' metacognitive monitoring ability [8]. Xin Yuechao pointed out that students can cultivate the habit of diligent

summary and reflection by writing reflective diaries. In reflective diaries, they can record their shortcomings in learning knowledge and problem-solving, clarify their thinking methods and actions, and then have thoughts, insights, and gains in summary and reflection [5]. Based on the guidance of metacognitive strategies, students can solve mathematical problems by providing self-prompts and finding solutions. After completing the problem-solving, students should reflect on the problem-solving process, including "Where did I get stuck just now", "Which details did I overlook when solving the problem", and "What was the key to solving the problem just now", and then summarize and record. This not only improves students' problem-solving efficiency but also subtly cultivates their self-reflection consciousness. Xin Yuechao also mentioned that students can modify or transform known conditions or conclusions to cultivate their ability to change a question; Finally, students analyze and summarize such related problems, clarify and understand the commonalities and differences of these problems, and ultimately solve a type of problem to achieve a state of multiple questions being unified [5]. Chen Jian believes that when assigning a new learning task, teachers guide students to review old knowledge based on the characteristics of learning resources, reflect on whether they have learned similar content, research methods, and learning situations before, and boldly guess the research methods of the new learning content. They guide students to reflect on the exploration process of the previous lesson, allowing them to transfer during review and guess during reflection. It can enable students to deeply understand the advantages of reflection and be willing to reflect in future learning, which is conducive to the cultivation of students' reflective consciousness [9].

4.3. Improving Teaching Evaluation System based on Metacognition

The role of teaching evaluation cannot be underestimated throughout the entire learning and teaching process. Through effective teaching evaluation, teachers can timely understand the many shortcomings in mathematics classroom teaching and adjust and optimize classroom teaching plans promptly. Through effective teaching evaluation feedback, students can understand their true learning situation, solve problems in their learning promptly, and improve learning efficiency. Li Hui believes that high school mathematics teachers should optimize and improve their teaching evaluation models based on metacognitive theory. On the one hand, in combination with high school mathematics classroom teaching monitoring, students' classroom participation, homework completion, mathematical learning ability, and thinking development should be included in the teaching evaluation, making it an important criterion for numerical value together with mathematics exam scores. On the other hand, students should also be guided to actively participate in evaluation. It is necessary to liberate students from the state of "passive acceptance of evaluation", guide them to evaluate themselves and other classmates around the given evaluation standards, and encourage students to form a clear understanding of themselves [6]. Li Na pointed out that in the learning of a single knowledge point, teachers can directly present the following questions to students: What content does the knowledge point need to master? What methods are you going to use to complete the learning of this knowledge point? After learning several knowledge points, encourage students to think about the reasons for the connections between them and encourage them to create mind maps, tree charts, etc. After completing the study, ask the students to say what they have learned and what content needs to be further supplemented. In this way, students' self-evaluation is initiated first and accompanied by the entire learning process, forming a clear understanding of themselves. This allows students who already have a relatively complete cognitive system to better update their self-awareness system. Based on this, teachers evaluate students again, and their self-awareness will shift from internal circulation to external circulation, completing a whole cycle of experience, not only improving cognitive ability, It can also enhance the quality of learning. Teachers, on the other hand, lay a more solid foundation for the implementation of teaching plans by receiving students' self-evaluation [1]. Li Na also mentioned that teachers must pay attention to students' emotional experiences during the evaluation process and combine it with monitoring of students' learning in the classroom to provide students with detailed positive and encouraging evaluations at the "point" level

[1]. This way, students can feel the teacher's attention to themselves more, and the closer their relationship with the teacher is, the happier their emotional cognition of mathematics will be, and their confidence in learning will also increase day by day [1]. Yu Ran pointed out that teachers should promptly evaluate students' learning outcomes, and the evaluation methods can also be more diverse, such as face-to-face, mutual, and self-evaluation. Secondly, teachers should also guide students to conduct self-evaluation, allowing them to summarize their learning outcomes orally or in writing, develop the habit of accumulating and categorizing incorrect questions, gradually improve their metacognitive monitoring and control level, and achieve the goal of improving their mathematical problem-solving ability [4]. Zhang Jingjing pointed out that students who are accustomed to conducting classroom summaries independently in mathematics learning perform very well in the classroom, and their thinking reactions are also quite agile. At the same time, they often put forward their different ideas for teachers or other classmates' answers. Classroom summary provides a lot of activity space for students' mathematical thinking in terms of energy conservation. Therefore, teachers should let students actively summarize and give them more opportunities to develop their mathematical thinking abilities [10].

5. Conclusion

This review extensively and deeply explores the effective application of metacognitive strategies in high school mathematics teaching. By reviewing relevant research and exploring practical applications, draw the following conclusions and summary.

Firstly, metacognitive strategies have significant potential value in high school mathematics teaching. They emphasize students' understanding of their learning process and encourage them to actively monitor and adjust their learning strategies. This not only helps to improve students' academic performance but also helps to cultivate their autonomous learning skills, enabling them to better adapt to the constantly changing learning environment.

Secondly, research has shown that applying metacognitive strategies in practical classrooms can have a positive impact. Educators can help students better understand and apply mathematical concepts by teaching metacognitive skills. In addition, metacognitive strategies can also help improve students' learning motivation and confidence, as they become more capable of coping with challenges and overcoming difficulties.

Thirdly, although metacognitive strategies have potential in high school mathematics teaching, their practical application faces some challenges. Educators need time and training to effectively integrate these strategies into their classroom teaching. In addition, students may need time to adapt to new learning and thinking styles. Therefore, the successful application of metacognitive strategies requires patience and firm determination.

Finally, to better promote the application of metacognitive strategies in high school mathematics teaching, further research and educational policy support are needed. Future research can delve into the effectiveness of different metacognitive strategies and how they match the needs of different student groups. Education policymakers can consider providing more educational resources and training to help educators better apply these strategies.

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