

# Exploring the cultivation strategies of logical thinking ability in middle school mathematics teaching

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**Abstract**—The teaching outline of full-time nine-year compulsory education clearly states that middle school mathematics teaching should actively cultivate students' logical thinking ability. In middle school mathematics teaching, cultivating students' logical thinking ability plays an extremely important role in improving their academic performance, mathematical analysis ability, and lifelong development. How to cultivate students' logical thinking ability based on their personality and cognitive differences has become a major issue faced by many middle school teachers. On the basis of elaborating on the current situation of cultivating logical thinking ability among middle school students, this article analyzes the reasons that affect the development of logical thinking ability among middle school students, and explores relevant strategies to improve students' logical thinking ability in middle school mathematics teaching.

**Index Terms**—Core competencies, Logic, Induction and deduction, Classification and comparison, divergent thinking.

## I. INTRODUCTION

The teaching outline of full-time nine-year compulsory education clearly states that middle school mathematics teaching should actively cultivate students' logical thinking ability. Cultivating students' logical thinking ability is not only a requirement of the teaching syllabus, but also a requirement for their own growth and the requirements of society for individuals. Under the background of quality education, there are further requirements for logical thinking ability, and mathematics is an important carrier for cultivating students' logical thinking ability. Therefore, middle school mathematics teachers not only need to follow and master the psychological logic of students learning mathematical knowledge, but also should fully consider the development of students' logical thinking ability, connect the teaching process with practical life, and gradually enhance students' logical thinking ability.

Some survey results both domestically and internationally indicate that in the process of middle school mathematics education, the cultivation of students' logical thinking ability plays a crucial role in improving their learning outcomes and mathematical analysis abilities [1-5]. In classroom teaching, appropriate teaching methods should be selected to combine theory with practice, in order to improve students' understanding of mathematical knowledge, and based on this,

logical thinking should be carried out on mathematical knowledge. Some high school teachers adopt a method that is not conducive to students' logical thinking, which is detrimental to their long-term development. In cultivating students' logical reasoning ability, the principle of timely evaluation and guidance should be followed to promote the development of logical reasoning. By improving the classroom teaching mode, changing teaching concepts, and using practical problems to enhance students' logical thinking ability; By encouraging students to express themselves, developing their divergent thinking, and teaching them mathematical language, their logical thinking ability can be improved. Emphasis should be placed on mastering basic concepts and knowledge. In the process of teaching basic knowledge, students should be taught certain ways of thinking, and after a detailed analysis of the logical relationship between conditions and conclusions, corresponding summaries should be made; The depth and breadth of development thinking, as well as the flexibility of thinking.

In traditional teaching methods, there are problems such as a single teaching form, no change in teaching concepts, and rigid teaching methods. These problems are not conducive to the development of students' logical thinking ability, and most teachers lack understanding of how to improve their logical thinking ability. In education, emphasis is placed on fundamental knowledge of the subject, while neglecting the logical thinking of students. To meet the future development needs of students, cultivating logical thinking ability in mathematics education has become a problem that teachers must explore.

This article mainly explores the following issues:

- (1) the current development status of logical thinking ability in middle school students;
- (2) The reasons and analysis that affect the development of logical thinking ability in middle school students;
- (3) Strategies for improving the logical thinking ability of middle school students in mathematics teaching.

## II. THE CURRENT DEVELOPMENT STATUS OF LOGICAL THINKING ABILITY IN MIDDLE SCHOOL STUDENTS

The logical thinking ability of middle school students has a certain impact on mathematics learning. For middle school

students, although their logical thinking ability has developed, due to the breadth and systematicity of their knowledge mastery, and the lack of specialized and complete logical thinking training, there are still certain deficiencies in their logical thinking ability. In addition, the influence of exam oriented education on Chinese middle school students, coupled with various external and internal pressures caused by the pressure of further education, makes it difficult for them to develop their thinking abilities, which is also one of the reasons for their shortcomings in thinking abilities. Specifically, there are the following manifestations.

Firstly, the logical thinking of middle school students lacks organization and organization. Under the influence of exam oriented education, teachers intervene more in student learning, making it difficult for students to take initiative in learning. Students have a lack of planning, organization, and purpose in their thinking and learning. When conducting logical reasoning, there is blind thinking based on the content and problem-solving skills of the question, thinking step by step, or making judgments based on intuition. For example, when encountering a "W-shaped parallel line", it is assumed to use an auxiliary line in between two parallel lines to solve the problem without thinking about what the problem is asking.

Secondly, middle school students lack flexibility in their logical thinking. During the process of learning mathematics, middle school students often receive too many exam oriented skills and lack opportunities for active thinking. In the process of solving problems, they often mechanically apply formulas and techniques, pursuing the correctness of the results and neglecting the thinking training during the problem-solving process. When students face specific problems, it is difficult to choose flexible and effective ways to solve them.

Again, the logical reasoning ability of middle school students is weak. Under the pressure of the middle and high school entrance exams, there is a situation where time is tight and tasks are heavy. Teachers often reduce the independent thinking and answering process of students when giving lectures, in order to save time and improve efficiency; Simply asking students to do something and then doing something has a significant impact on the cultivation of their logical thinking ability. When students face the questions taught by the teacher, they will easily solve the problems according to the steps taught by the teacher. However, when they face questions that the teacher has not explained before, their brains will go blank; I don't know where to start. When encountering algebraic problems, he randomly calculates, and when encountering geometric problems, he casually draws a few auxiliary lines; These all indicate the shortcomings of students in logical thinking.

Finally, middle school students lack the ability to think in reverse. Logical thinking ability includes forward thinking ability and reverse thinking ability, and these two are actually two sides of the same problem, which are interdependent. During the learning process, students are accustomed to using positive thinking to solve problems, rather than focusing on reverse thinking. Some teachers still use traditional teaching methods in their teaching, memorizing formulas and concepts through rote memorization. However, students do not

understand the fundamental meaning of formulas or concepts, which will inevitably reduce their learning quality and hinder their development of reverse thinking. For example, in the teaching of geometry in middle schools, teachers usually start from the known and explain the problem-solving process to obtain conclusions. However, when students independently solve problems, they often encounter situations where they cannot deduce conclusions from known conditions. In this case, students often need to reverse deduce known conditions from the conclusions, or deduce the problem-solving process from known conditions and conclusions to the middle. [6] examined the development and refinement of possible mathematical models for the intellectual system of career guidance. Mathematical modeling of knowledge expression in the career guidance system, Combined method of eliminating uncertainties, Chris-Naylor method in the expert information system of career guidance, Shortliff and Buchanan model in the expert information system of career guidance and DempsterSchafer in the expert information system of career guidance method has been studied. [7] discussed that according to the observations in this paper, an existing mathematical model of banking capital dynamics should be tweaked. First-order ordinary differential equations with a "predator-pray" structure make up the model, and the indicators are competitive. Numerical realisations of the model are required to account for three distinct sets of initial parameter values. It is demonstrated that a wide range of banking capital dynamics can be produced by altering the starting parameters.

### III. THE REASONS THAT AFFECT THE DEVELOPMENT OF LOGICAL THINKING ABILITY IN MIDDLE SCHOOL STUDENTS

The new mathematics curriculum objectives clearly state that in teaching, emphasis should be placed on cultivating students' mathematical thinking ability, especially their mathematical logical thinking ability. According to Piaget's cognitive development theory, middle school students are in the stage of formal operations, and their thinking develops to the level of abstract logical reasoning. The ability of logical thinking plays an important role in learning mathematics well, and it is also an indispensable ability for mastering other subjects and solving daily life problems. However, the development of logical thinking ability among students is often asynchronous, and there are more or less differences between individuals. The main factors affecting the development of logical thinking ability among middle school students are as follows.

#### A. Intrinsic factors

##### (1) Personality traits of students

The personality traits of students are one of the reasons that affect the development of their logical thinking ability. Logical thinking ability is actually a rational activity carried out by the brain, rather than a sensory activity. It is a standardized, rigorous, and repeatable activity. The process of developing students' logical thinking ability is a process of calm thinking and analysis. Students gradually develop the habit of questioning and analyzing things in their thinking. If a student has a irritable personality and cannot calmly think when encountering problems, naturally they will not be able

to smoothly engage in logical thinking. Educator Ananyev pointed out that "the development of ability and personality is closely related.". The process of cultivating students' logical thinking ability is actually the process of cultivating their personality. Numerous educational studies have also shown that among the many factors that affect the development of students' mathematical abilities, personality factors play a decisive role [9], and logical thinking ability also belongs to mathematical ability.

(2) Students already have knowledge reserves

The existing knowledge reserves of students affect their development of logical thinking ability. Good logical thinking ability is the process of comprehensively applying basic knowledge. The increase of knowledge will affect the judgment of logical thinking, and a large amount of knowledge will also support complex logical thinking. With the continuous progress of human society, human knowledge is also constantly becoming richer, and the limits of complex logical thinking are also constantly increasing. For example, if Marx had lived in the Qin Dynasty, he could not have written Capital. To write a work that covers multiple disciplines and fields, reflecting the universal laws of world operation, it is necessary to have complex logical thinking in order to achieve clear, fluent language, and orderly organization. Some people habitually express their opinions in a vague manner because there are loopholes in their knowledge base, which affects their logical thinking.

(3) The language expression ability of students

The language expression ability of students can affect the development of logical thinking ability. Language expression ability can promote the development of logical thinking. When students want to try to express their ideas in language, they need to organize and organize knowledge in their minds, so that their expressions can be understood and accepted by others, and this process can promote the development of logical thinking in students. Speech language pathologists point out that language ability does not directly affect logical thinking ability, but it can indirectly affect the progress and development of logical thinking. Poor language expression ability can affect students' early education and knowledge learning, as well as their knowledge accumulation and cognitive development. In addition, language expression ability can affect communication and interaction between people. Poor language expression ability can lead to barriers in interpersonal relationships and affect normal logical thinking development.

(4) Student's imagination

Cultivating students' imagination can improve their level of logical thinking. Imagination is the foundation of creativity and creation, and the generation of imagination is the result of the joint development of logical and visual thinking. The process of imagination requires not only visual thinking, but also logical thinking. It is the process in which the brain logically disassembles objective things, and then makes assumptions and recombines them based on visual thinking. Some scholars believe that imagination belongs to the category of brain thinking and is mainly controlled by visual thinking, so it cannot promote the development of

logical thinking. However, in reality, imagination is not only controlled by visual thinking, but also the result of the coordinated development of visual thinking and logical thinking.

*B. External factors*

(1) The atmosphere of the class

The atmosphere of the class collective is greatly influenced by the personality traits of the class teacher and the core characteristics of the class leadership, and the class will present different spiritual atmospheres. Some class groups have a common goal of striving, presenting a positive, progressive, lively and enthusiastic class atmosphere, while others exhibit a scattered, lazy, and asynchronous spirit, which to some extent affects the development of mathematical and logical thinking abilities of students in the class group. A good classroom atmosphere can provide students with a relaxed learning attitude, which can stimulate their learning enthusiasm, disperse their thinking, analyze and think deeply about problems, and promote the development of their logical thinking ability. Therefore, teachers often strive to build a relaxed learning environment for students in their teaching, thereby promoting their cognitive development.

(2) Teacher's teaching mode

Under the pressure of the baton of exam oriented education, time is tight and tasks are heavy. Some teachers may engage in rote and rote teaching, and the knowledge points that should have been discovered by students through exploration become forcibly imparted by teachers to students, becoming a memory burden for students. A large amount of study time is spent doing exercise questions, lacking opportunities for independent thinking and initiative. In knowledge teaching, teachers habitually focus on the teaching of theoretical knowledge and problem-solving skills. Students do not need to think, but only need to mechanically apply skills, resulting in a lack of links in cultivating students' logical thinking ability in teaching. Students become learning machines, which is not conducive to the development of their logical thinking ability. Educators should transform their educational philosophy, truly achieve guided teaching, leave students time for thinking, inspire independent thinking, stimulate their learning enthusiasm, and promote the development of logical thinking.

(3) Family education concept

School is the main place for students to learn, but for their development, the concept of family education is also crucial. The idea of parents expecting their children to succeed makes them unconsciously impose their own ideas and opinions on students during the education process. Students lack initiative in the growth process and only passively develop according to their parents' expectations, which limits their thinking. Under the pressure of the middle and high school entrance exams, parents will enroll their students in various tutoring classes, math Olympiad classes, and so on. Firstly, strong exam taking skills hinder students' initiative in thinking, turning active learners into passive recipients of knowledge. Secondly, it reduces opportunities for students to entertain and create. Some families also respect the wishes of their

students and create a relaxed, open and innovative family atmosphere that conforms to the laws of their physical and mental development, which promotes the improvement of their logical thinking ability.

#### IV. STRATEGIES FOR IMPROVING STUDENTS' LOGICAL THINKING ABILITY IN MIDDLE SCHOOL MATHEMATICS TEACHING

Below, we will elaborate on how to promote the development of students' logical thinking ability in middle school mathematics teaching from four aspects: emphasizing basic knowledge teaching, inspiring independent thinking, utilizing multimedia teaching, and conducting logical thinking training.

##### *A. Promoting the development of logical thinking through basic knowledge teaching*

The cultivation of logical thinking is a process of in-depth understanding of the learned content and flexible application based on it. When conducting logical reasoning, it is necessary to have a solid foundation to ensure that each step of reasoning can be carried out well, thereby providing sufficient basis for the results of reasoning. Basic knowledge and logical thinking are interdependent. A solid foundation of knowledge can promote the development of logical thinking, while excellent logical thinking can promote students' mastery of basic knowledge. When conducting logical thinking training for students, it can achieve good results. Logic is a rational way of thinking, but in order for logical thinking to develop, it must be based on intuitive knowledge. It is necessary to form a concrete, vivid, and intuitive understanding of knowledge, and then carry out in-depth abstraction, analysis, and reasoning of knowledge, so as to develop logical thinking and promote the development of logic.

##### *B. Inspire students to think independently and promote the development of logical thinking*

Under the influence of traditional teaching methods, teachers are accustomed to explaining the knowledge content in textbooks based on their own teaching plans, breaking down the knowledge points and providing detailed explanations to students for easy understanding and absorption, in order to avoid students not fully understanding the details of knowledge and affecting their academic performance. This teaching mode can certainly help students memorize or even memorize knowledge points, but it often leads to passive learning situations for students. Students passively move forward according to the teacher's pace, lacking initiative and opportunities for independent thinking during the learning process. This not only makes it difficult to promote the development of students' logical thinking ability, but also has an impact on their learning effectiveness and the quality of the teacher's teaching. Therefore, teachers should inspire students to think independently and create a positive and proactive environment in the classroom

##### *C. Utilizing multimedia teaching to promote the development of logical thinking*

In the context of a new round of quality education, traditional teaching models and technological means can no

longer meet the needs, and computer-aided teaching has rapidly developed in this context. As frontline teachers, we should adjust our education methods in a timely manner according to the curriculum reform requirements of the Ministry of Education, keep up with the pace of the times, and enhance our awareness of using modern science and technology.

When explaining more abstract mathematical models, teachers can use computer animation models to show students, expand the amount of information in teaching, achieve the combination of numbers and shapes, concentrate students' attention, turn abstraction into concrete, and promote their understanding of knowledge. Students have shifted from relying solely on listening and speaking to actively engaging in learning. By using multimedia teaching, not only can students understand knowledge more easily, but teachers can also impart knowledge more easily. This can stimulate students' interest in learning, cultivate their creative thinking, and improve their ability to analyze and solve problems.

##### *D. Conduct logical thinking training to promote the development of logical thinking*

In middle school mathematics teaching, teachers can promote the development of logical thinking in students by teaching them thinking skills. For example, when learning about plane intersection, students can be asked, if there are three planes intersecting in space, how many intersecting lines will there be? Students can think about their answers and provide reasonable explanations. Questions with multiple answers like this can promote openness in their thinking, not only understanding the concepts of plane intersections and intersecting lines, but also promoting the development of their logical thinking.

Problem solving is an essential part of the learning process for students. When encountering problems, students need to first analyze the logical relationship between the problem conditions and conclusions, and then choose the problem-solving method. This process can promote the development of students' logical thinking. Teachers should first present students with relatively simple questions. After students have fully mastered the problem-solving ideas and methods of this type of question, they should gradually increase the difficulty of the question and stimulate students to think. Through repeated training and gradually deepening the difficulty of knowledge, students can diverge their thinking and promote their thinking development.

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