Analysis of the Application of Mathematical Beauty in Middle School Mathematics Teaching

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Abstract—*Mathematics is a natural product of the development of human intelligence. It not only has strong logic, but also involves a wide range of knowledge points and has penetrated into all aspects of people's lives. The aesthetic value of mathematics is very important, and allowing students to experience the beauty of mathematics and the true essence of it during the learning process is currently a key focus that needs to be implemented. Therefore, this article focuses on the application of mathematical beauty in middle school mathematics teaching. Based on the analysis of the intersection points of problems, it mainly introduces the theoretical basis of mathematical beauty, combines theory and practice, and refines the application path from two aspects: new teaching in middle school mathematics and problem-solving in middle school mathematics. To reflect the important value of mathematical beauty in teaching, and to make mathematical beauty and mathematical teaching complement each other.*

Keywords— *Mathematical beauty, Middle school mathematics, Strange beauty, Simple and beautiful, Symmetrical beauty.*

I. INTRODUCTION

A. Research background

With the development of the times, people are paying more and more attention to the value of mathematical beauty. In the research of middle school mathematics teaching, it is not only necessary to teach students to accumulate knowledge, but also to guide their comprehensive development and reasonable infiltration of mathematical beauty. For learners of mathematics and applied mathematics, it is also necessary to re-examine teaching concepts. On the one hand, it is necessary to meet the needs of exams, and on the other hand, it is necessary to integrate scientific and humanistic values with aesthetic literacy, in order to maximize the aesthetic impact of mathematics education. For mathematics and applied mathematics, it is not only a science, but also an art. In middle school mathematics teaching, while conveying some mathematical knowledge and basic mathematical principles, it is also necessary to pay attention to and disseminate the mathematical beauty contained therein. In the current reform of mathematics education, it is necessary to clarify the development direction of mathematical aesthetic education. Mathematics educators should combine reality, create teaching scenarios of mathematical beauty, enhance learners' participation, and enhance their interest. The logic of mathematics is relatively rigorous, but mathematics is ultimately beautiful. Applying mathematical beauty in middle school mathematics teaching can not only improve students' attitudes towards mathematics, but also promote their future development and progress. In view of this, how to increase the application of mathematical beauty in teaching has become a focus and difficulty that needs to be explored.

B. The significance of research

In the process of mathematics learning, developing students' thinking ability and improving their aesthetic ability is an essential part. The image of beauty can promote students' interest in learning and strengthen their intellectual development. This article explores the application of mathematical beauty in middle school mathematics teaching, introduces specific teaching content and teaching cases, explores the characteristics of applied mathematical beauty, and seeks methods for problem-solving ideas. It provides a foundation for future research and has strong theoretical and practical significance.

II. THEORETICAL BASIS

A. Mathematical Beauty

The so-called beauty of mathematics belongs to an intuitive phenomenon. To further emphasize the beauty of mathematics, it is necessary to combine science and humanities. The beauty of mathematics is often hidden in mathematical objects, which can be simple mathematical language, beautiful mathematical formulas, clever problem-solving methods or ideas, all of which are manifestations of mathematical beauty.

B. Classification of Mathematical Beauty

Mathematical beauty has certain characteristics, demonstrating strong features such as simplicity, unity, symmetry, singularity, etc. Simplicity beauty: Simplicity is the fundamental characteristic of simplicity beauty, and mathematical symbols, formulas, and theorems demonstrate the characteristic of simplicity beauty everywhere. Symmetry beauty: Symmetry is a fundamental feature of symmetry beauty, and the symmetry contained in geometric figures, theorems, and other contents belong to these categories [4]. Unity beauty: Unity is the fundamental characteristic of unity beauty. Unity not only exists in mathematical concepts, but also in mathematical thinking methods. Strange beauty: Singularity is the fundamental feature of strange beauty, and irrational numbers are a novel and peculiar new concept, which is precisely the singularity of mathematics. Inner rational beauty: Inner rational beauty is mainly reflected in the

logical beauty, abstract beauty, and language beauty of mathematics. When understanding the mathematical essence of things through abstraction and generalization, it is also a process of inner rational beauty.

III. THE APPLICATION OF MATHEMATICAL BEAUTY IN MIDDLE SCHOOL MATHEMATICS TEACHING

A. The Application of Mathematical Beauty in the New Teaching of Middle School Mathematics

(1) Creating a Beautiful Context

Be good at discovering with your eyes, but beauty is actually around us. Middle and high school mathematics textbooks have been effectively reflected to a large extent in terms of mathematical culture and aesthetic value. Through the application of knowledge related to mathematical beauty, everyone can feel the beauty of mathematics and experience the "temperature" of mathematical beauty. The methods of creating mathematical and practical situations can not only stimulate students' interest in learning, but also greatly stimulate their thinking and deepen their understanding of knowledge. Teachers should be familiar with the content of the textbook, be good at utilizing the strange beauty of mathematics, and concentrate students' attention.

For example, mathematical bizarre and beautiful stories can be used to attract everyone's attention. When the king and commoners play chess, they need to put wheat kernels on the chessboard. In the first grid, they need to put two kernels, and in the second grid, they need to put four kernels... This has always been the case, with the latter being twice as large as the previous one, requiring a total of 64 squares to be filled. So at this point, if you are the king, how much does the last grid need to be placed? In mathematical aesthetics, it can be known that the result is 2^{64} particles. It is precisely the strange beauty of mathematics that can stimulate the interest in learning mathematics, increase the desire to explore, and perceive the charm of mathematics.

(2) Teaching New Knowledge from the Perspective of Beauty

In the process of implementing mathematics teaching, it is often necessary to follow a certain logical order for teaching. In general, it can be divided into the following parts: (a) Creating a context; (b) Teaching new knowledge; (c) Example explanation; (d) Exercise exercises; (e) Classroom summary; (f) Homework after class [6]. The teaching of new knowledge generally focuses on mathematical concepts, theorems, formulas, etc. At this time, it is difficult for students to accept rigid teaching. However, using mathematical beauty can stimulate students' interest in learning and guide them to appreciate mathematics from a beautiful perspective.

For example, in the definition of the concept of hyperbola, if there is no "less than $|F_1F_2|$" in the definition, the trajectory belongs to two rays or does not exist. This not only increases the logic of mathematics, but also demonstrates the inherent logical beauty of mathematics. From the image of the hyperbola, please refer to Figure 3-1 for details. Here, you can see the visual beauty and perceive the symmetrical graphic beauty of the axis. In the transformation of constants,

hyperbolas also give everyone a dynamic beauty, which not only strengthens students' interest but also improves their aesthetic ability, providing basic preparation for future mathematical learning.
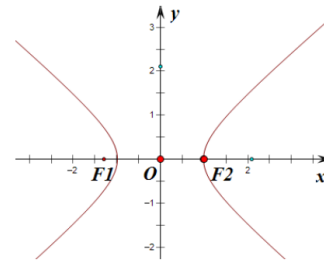

Figure 3-1. Hyperbolic image

(3) Using mathematical beauty to help students memorize knowledge after class

The teaching of mathematics requires understanding and memorizing many mathematical concepts. When memorizing these knowledge, it is necessary to first understand them. If memorizing them solely for the sake of memory, it will not achieve satisfactory learning outcomes. Even if students memorize knowledge points based on understanding, they can still find some beautiful methods to present these scattered knowledge more clearly in front of everyone. This can help students better assimilate, understand, and summarize new knowledge, and reduce confusion.

For example, in the "parallelogram", it is easy to confuse some knowledge, especially their respective properties. In order to further deepen the understanding of these contents, tables can be used to present them. The main purpose is to deepen understanding, enhance the connection between various parts, and improve students' flexible use of knowledge.

(4) Using multimedia to present mathematical beauty and assist teaching

In today's rapidly developing era of information technology, the use of information technology and multimedia technology in mathematics teaching can enable students to more intuitively perceive the beauty of mathematics, attract attention, and stimulate the classroom atmosphere. Combining pictures, music, images, videos, etc. in teaching, this form of "beauty" can further promote students' understanding of knowledge. In middle school teaching practice, modern information technology can help students find truth in mathematical aesthetics, and it is best presented through multimedia. The ways in which computers are presented are diverse, and at this point, educators need to be proficient in using information technology tools in order to present students with more stunning mathematical beauty.

For example, when the "basic elementary function" in high school mathematics constantly changes with the base a, the exponential function image will also change according to a certain pattern. Choose the "Draw" | "Define Coordinate System" command, then use the "Hide Grid" command to draw the line segment BC, measure the length of BC, and

change the label to a. Click on the line segment a to obtain the image of the function $y = a^x$. Please refer to Figure 3-2 for details.
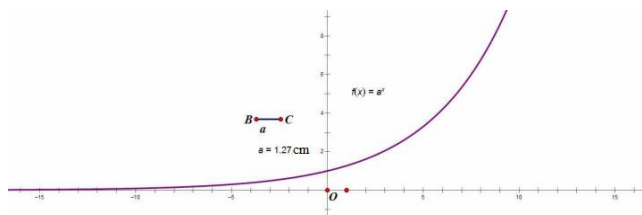

Figure 3-2. Exponential function image

B. *The Application of Mathematical Beauty in Middle School Mathematics Problem Solving*

(1) Pursuing simplicity and beauty, searching for problem-solving ideas

For middle school students, when solving problems, they can also use mathematical beauty to enhance their problem-solving thinking. When calculating the range of function values, using methods such as substitution and collocation can simplify the calculation method and improve the accuracy of the answer. Mathematical language has a highly refined and concise nature, and at this point, it is necessary to guide students to analyze problems from the perspective of mathematical beauty. Only by extracting valuable information can we clearly understand the essence of mathematical problems and optimize problem-solving strategies.

For example, when calculating

$$\left(\frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{2018}\right)\left(1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{2017}\right)$$
$$- \left(1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{2018}\right)\left(\frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{2017}\right),$$

this method can be used, using the "overall substitution method", which can achieve simplification and reflect the beauty of mathematical form, making the solution much easier.

(2) Utilize symmetry beauty to gain inspiration for problem-solving

In the algebraic part, the symmetry of mathematical expressions or structures is relatively common. Many times, you can find that many mathematical forms are beautiful, and students may not necessarily recognize them. However, their understanding of symmetrical beauty is generally well-known. By using beauty as a symmetrical positioning in the depths of the soul, the difficulty of learning will be reduced and more inspiration for problem-solving can be obtained.

For example, in the linear symmetry problem, AA=BB, based on the origin symmetry, can obtain a line that can be symmetrically transformed, and this line is AA=BB Finding appropriate auxiliary lines will enable everyone to find a solution to the problem in the shortest possible time. This approach not only embodies the beauty of mathematics, but also to a certain extent, achieves simplified mathematical calculations.

(3) Seeking Unity Beauty and Finding a Breakthrough in

Solving Problems

The pursuit of unified thinking can provide a new way of thinking for everyone's problem-solving. Under the integration of harmony and unity, students are more likely to find corresponding breakthroughs. Just like the normal distribution density curve problem in the probability part, this method can be used to solve the problem using a number axis or Venn chart. When analyzing geometric related problems, one can use the conic curve definition to solve the curve equation and obtain the final solution idea. For the beauty of mathematics, it is the driving force for everyone to discover problems and explore the essence. In this path, it is not something that can be achieved in a short period of time. It requires long-term establishment of connections and the use of mathematical beauty methods to effectively reflect the characteristics of mathematical beauty.

For example, when learning the "statistical part", students can use distribution histograms, stem leaf plots, scatter plots, and other related methods to seek unified beauty, guide students to analyze problems, and gradually supplement and improve the required items. Only when students feel the beauty of these mathematical problem-solving processes can their thinking be further expanded.

(4) Using strange beauty to inspire problem-solving ideas

In the process of solving mathematical problems, such singularity itself demonstrates different mathematical ideas and can greatly enhance the connection between these contents [6]. The charm contained in strangeness is quite amazing for learners to use and can also stimulate their curiosity. This approach belongs to a type of reverse thinking, which can give people advanced imagination and make problems simple. At the same time, it also presents the beauty of simplicity to everyone's vision, reasonably promoting students' innovation awareness and ability, and maximizing students' comprehensive abilities.

For example, given $x^2 + y^2 + xy = 19$, find the maximum value of $x^2 + y^2$.

When solving this problem, corresponding solving equations can be set. Substituting the coordinate equation

$$\begin{cases} x = \rho \cos\theta \\ y = \rho \sin\theta \end{cases}$$

into known conditions, after a series of sorting, the maximum value is 38 and the minimum value is $\frac{38}{3}$. The unique idea of mathematical singularity provides a new breakthrough for problem-solving, which can further combine with practical situations to train students' mathematical thinking, allowing them to perceive different strangeness and beauty. In the long run, students' thinking will also be exercised, providing a good foundation for further learning mathematics in the future.

IV. CONCLUSION

This article focuses on "Middle School Mathematics" and explores the application of mathematical beauty in middle school mathematics teaching. When the beauty of simplicity

and symmetry are presented to everyone, a different teaching context can be created, allowing students to perceive the true essence of mathematical beauty. We should not only establish a science that conforms to the beauty of mathematics in the mathematics classroom, but also enhance students' cognition, perception of mathematical beauty, mastery of basic mathematical knowledge, and improvement of application value. Here, we mainly explore from two directions: new teaching in mathematics and problem-solving in mathematics. What's better is to explore the beauty hidden in mathematical knowledge, organically combine mathematical knowledge with mathematical beauty, stimulate students' interest in learning mathematics, enhance their understanding of mathematical charm, and help them strengthen their memory. Find ways to solve problems based on the characteristics of mathematical beauty, train students' mathematical thinking, and maximize their problem-solving ability. When students can discover and comprehend the beauty of mathematics, their internal drive and confidence in learning will be enhanced, their interest in learning mathematics will also increase, and their physical and mental development will also be comprehensive. Due to my limited academic background, the content of comparing it with traditional teaching methods is not yet well developed. I hope to further research mathematics and its applications in my future studies based on practical situations.

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