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Implementing Abstraction Ability Literacy in Junior High School Mathematics Classroom Teaching: Strategies to Apply

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

As one of the core literacies of mathematics at the junior high school level, the abstraction ability literacy is attracting widespread attention. Classroom teaching has always been the mainstay of subject teaching and is the main way for students to acquire knowledge and skills. Therefore, how to implement abstraction ability literacy through classroom teaching is a problem worth studying. This article provides an in-depth analysis of the abstraction ability in *Mathematics Curriculum Standards for Compulsory Education (2022 Edition)* by theoretical research methods. Based on the definition and requirements, the current situation of mathematics classroom teaching is clarified, and four strategies for implementing abstraction ability literacy in classroom teaching are proposed: (1) Combining problem scenarios, letting students experience the process of generating mathematical knowledge; (2) Carefully designing practice topics, carrying out homogeneous and variant training, and strictly regulating mathematical language expression; (3) Organizing interdisciplinary comprehensive practical activities centered on mathematics; (4) Flexibly using modern information technology to assist classroom teaching. Hopefully, it can provide new ideas for junior high school mathematics classroom teaching.

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1. INTRODUCTION

The core literacies were formally condensed in *Mathematics Curriculum Standards for Compulsory Education (2022 Edition)* (hereinafter referred to as the *Curriculum Standards (2022)*) in China. At the compulsory education level, the mathematical perspective is mainly manifested in the following ways: abstraction ability (including number sense, quantity sense, and symbolic sense), geometrical intuition, spatial conception, and creative consciousness. Abstraction ability mainly refers to the ability to obtain the object of mathematical research and to form mathematical concepts, properties, rules, and methods through the abstraction of quantitative relations and spatial forms in the real world [1]. The abstraction ability in junior high school is an extension of the number sense, quantity sense, and symbolic awareness in primary school, and the foundation of mathematical abstraction in senior high school, which has a connecting role in content. Therefore, abstraction ability is one of the mathematics key competencies that junior high school students must possess. Since the introduction of mathematics key competencies, mathematics education has gradually shifted from a 'knowledge-based' to a 'literacy-based' approach [2]. The mathematics classroom is the main environment and pathway for middle school students to acquire knowledge and cultivate their abilities. The teaching behaviors of teachers, learning behaviors of students, and mathematical reflectivity in junior high school mathematics classrooms have a significant positive impact on mathematical core literacies [3]. Therefore, it is particularly important to implement abstraction ability literacy in junior high school mathematics classroom teaching. What are the connotations and training objectives of abstraction ability? What is the current situation of junior high school mathematics classroom teaching? How to implement abstraction ability literacy in junior high school mathematics classroom teaching? These are all thought-provoking questions.

2. THEORETICAL ANALYSIS

Compared with the *Mathematics Curriculum Standards for Compulsory Education (2011 Edition)*, abstraction ability is a newly added concept in the Curriculum Standards (2022), which is one of the core literacies necessary for students in the new context. The connotation and requirements of abstraction ability literacy in the Curriculum Standard (2022) are expressed as follows [1].

2.1 The Connotation of Abstraction Ability Literacy

Abstraction ability mainly refers to the ability to obtain the object of mathematical research and to form mathematical concepts, properties, rules, and methods through the abstraction of quantitative relations and spatial forms in the real world.

The real world is an objective world that exists outside the human brain, and things and their interrelationships are within the real world. The quantitative relationship is the relationship (or structure) between two or more numbers (or expressions), such as size, multiples, inclusions, etc. The spatial form includes the expressive characteristics of things in space, such as shape, volume, etc., as well as the position, structure, and other relationships in space. Abstract, as a psychological term, refers to the thinking process of comparing and identifying the general characteristics of things, extracting their essential attributes, and setting aside their non-essential properties [4]. The research object of mathematics is mainly the quantitative relationships and spatial forms in the real world. Mathematical concepts, properties, rules, and methods are the main knowledge in mathematics.

Therefore, the abstraction ability is the ability to find out the general characteristics of 'number' and 'shape' of things in the objective world through comparison, extract the essential attributes of things, obtain the mathematical objects that need to be studied, i.e., quantitative relationships and spatial forms, and then to obtain mathematical knowledge.

2.2 The Requirements of Abstraction Ability Literacy

2.2.1 Be able to abstract core variables, patterns of variables, and relationships between variables from real-world situations or interdisciplinary problems, and to express them using mathematical symbols

The actual situation comes from the background of real-world problems or mathematical problems

encountered in daily life, which are closer to life and more realistic, such as the problem of stepped water charges. Interdisciplinary problems require the application of multidisciplinary knowledge, methods, systems, and practices to be solved, such as 'Design of Speed Bump Spacing [5]', which is mainly related to mathematics and physics. A variable is the amount of change that occurs during a certain process, which refers to the state of things, such as the age or the gender of a person. The core variable is the key to the problem and determines the direction of the solution. Laws are the inevitable, essential, stable, and recurring relationships between various phenomena in nature and society. Relationships are states in which things interact and influence each other. Mathematical symbols are a concise and generalized language that adapts to the abstract and formal characteristics of mathematics. Expression is the act of reflecting the results of thinking through language or other means.

The requirement requires students to be able to distinguish the variables that play a decisive role in complex situational or real-life problems, to clarify the essence of variables in the problem, the stable and recurrent relationships between variables, and to clarify how variables interact and influence each other. Then, Life problems can be transformed into mathematical questions and expressed in the mathematical symbolic language during the solving process.

2.2.2 Be able to summarize general conclusions from specific problem-solving and form mathematical methods and strategies

'Specific' refers to not being abstract, not being general, with clear details, and also refers to what exists and is real. Problem-solving is the process of applying various cognitive activities, skills, etc. according to a certain goal, triggered by a certain context, through a series of thinking operations, to solve a problem [6]. Generalization is the process of thinking that combines several common attributes of abstracted things and applies them to a certain class of things, making them universal. Conclusions are summaries of judgments of things as a result of inferences from certain premises. The methods and strategies of mathematics are centered around methods and strategies, described by mathematics, and are methods and strategies that use mathematics as a tool to solve real-world problems.

This requirement requires students to be able to apply various methods and means according to certain goals in the process of solving specific problems and infer results based on prerequisite conditions so that the problem can be solved. In this process, clarify the commonalities and characteristics of this type of problem, promote the solution and results, draw general and universal conclusions, and then habitually use mathematical perspectives, thinking, and language to solve problems encountered.

3. ANALYSIS OF THE CURRENT SITUATION OF JUNIOR HIGH SCHOOL MATHEMATICS CLASSROOM TEACHING

In terms of teaching methods, teachers often play a dominant role in the classroom, while students have relatively less participation and opportunities to speak. Almost all teaching tasks and speaking opportunities are completed by teachers, and students only passively receive knowledge in the classroom, with few opportunities to participate in discussions and raise questions. Even if there is a group discussion session, students do not know how to conduct the discussion or what the activity objectives are. In such an environment, students lack the willingness to actively participate, and they directly conclude the guidance of teachers, rarely experiencing the process of knowledge generation.

In the math classroom, the teaching process is not perfect, often neglecting the introduction of new courses and directly starting new course teaching. A good introduction process can quickly attract students' interest and achieve a transition between the mathematics classroom and real life. A lack of introduction process can lead students to enter the learning of new knowledge unprepared. Secondly, there is a lack of problem scenarios. The content of junior high school mathematics is relatively complex, and students' abstract thinking ability is in the stage of development and maturity [7]. Pure mathematical knowledge is too dull, without the support of reasonable mathematical scenarios, students have certain difficulties in understanding. Finally, teachers do not have enough time for students to think independently, and students enter a new learning stage before internalizing knowledge, which is not conducive to students' deep understanding and integration of knowledge.

In terms of teaching tools, although information technology has been widely used to assist teaching in actual mathematics teaching, some teachers are limited to the surface level in the application of information technology [7], and cannot use technology reasonably in conjunction with the course content. For example, in teaching about spatial forms, in addition to the simple display of the shape of the object, you can also show animation through Geogebra, so that students can feel the process of spatial change.

In terms of practice design, the materials are rich, the questions are complex and diverse, and the after-school homework training is sufficient. However, the long-standing mechanical training and 'question sea tactics' cannot make students skillful and bypass by analogy. In mathematics classroom teaching, there is a lack of careful design of training questions, which makes it difficult to help students summarize general conclusions draw inferences, and widely promote them. Instead, students are in a state of 'solving problems one by one, achieving half the result with twice the effort' [8].

4. HOW TO IMPLEMENT ABSTRACTION ABILITY LITERACY IN JUNIOR HIGH SCHOOL MATHEMATICS CLASSROOM TEACHING

In order to truly implement abstraction ability literacy in junior high school mathematics classrooms and improve the current negative phenomena in classroom teaching, it is recommended that teachers adopt the following strategies.

4.1 Combining Problem Scenarios, Let Students Experience the Process of Generating Mathematical Knowledge

This strategy requires teachers to first understand the process of knowledge generation, construct reasonable mathematical scenarios, and then attract students' interests, so that students personally involved in the introduction, generation, generalization, and promotion process of knowledge, feel the close connection between mathematics and life. Li J and others also agree with these points [9-12].

Mathematics and life have a close connection, life cases can compensate for the dryness of mathematical theory. Solving life problems with mathematical theory can enhance the practicality of knowledge [13]. The introduction of abstraction ability literacy in the Curriculum Standard (2022) also repeatedly mentions real-life backgrounds, such as 'real world' and 'actual situations', which all emphasize the abstraction of mathematical problems from real context, solving mathematical problems, and obtaining mathematical conclusions and methods.

The problems encountered in the development of mathematics in history are also problems in today's students' learning [14]. Experiencing the process of knowledge generation firsthand, feeling that mathematics is abstracted from life, and then used to solve problems in life, feeling the history of knowledge generation, so that students can view today's abstract mathematical knowledge from a higher perspective. However, in current classroom teaching, teachers dominate the classroom, and students are always passively accepting mathematical knowledge taught by teachers, lack connection with life situations, and seldom experience how knowledge is generated.

Therefore, teachers should increase student activities in the classroom, let students understand the history of mathematics, design problem contexts, let students experiment, guess, prove, and summarize, and personally experience the process of mathematical knowledge from a problem to a truth.

4.2 Carefully design exercise questions, conduct isomorphic and variant training, and strictly regulate mathematical language expression

This strategy requires teachers to select practice questions and conduct thematic teaching on topics with similar or opposite characteristics, based on the course content and the knowledge and skills goals that students should achieve. At the same time, strictly regulate students' mathematical expression in practice, including oral and written language, and establish the relationship between mathematical symbols and language. Furthermore, it is hoped that students can experience the changes and invariance in specific problem-solving, summarize general conclusions, and form a system of problem-solving methods.

In the requirements of Curriculum Standards (2022), learning to summarize and generalize independently, promoting application, and improving one's knowledge structure an important parts of the development of abstraction

ability. Problem-solving exercises are the most direct process for students to apply mathematical knowledge to solve problems, and symbol language is used intensively in this process. At the same time, the current exercises are diverse and numerous. In the absence of a logical system, each problem is different for the student and they cannot solve many problems at once.

Abstraction is a process of discovering general features. According to the requirements of the Curriculum Standard (2022) on students' ability to generalize and promote their mathematics expression ability, as well as the current status quo of the current practice problems which are complicated and lack logic, teachers should organize homotypic and variant training, so as to facilitate students to naturally compare the similarities and differences of the topics and solutions, and to realize the integration of one into the other. In this process, students' mathematical expressions should be strictly regulated to achieve the proficient application of symbolic language.

4.3 Organize Interdisciplinary Comprehensive Practical Activities Centered on Mathematics

This strategy requires teachers to combine the knowledge of mathematics courses and collaborate with other subject teachers to design practical activities, allowing students to abstract life problems into mathematical problems and experience the process of exploring and solving them firsthand. In this process, they learn to solve problems, cooperate, share, and seek help.

Interdisciplinary practice activities in junior high school mathematics can provide students with real-life scenarios for knowledge application and help them accumulate rich experience in mathematical activities [5]. Experiencing the process of transforming real scenarios into mathematical problems and returning to life after solving mathematical problems, helps students establish the relationship between the real world and abstract mathematics. Students experience the general characteristics of the core variables in a problem through fieldwork and reviewing information, and then they can accurately grasp the direction when solving different problems.

Compared to the current single teaching method, dull classroom learning, and after-school exercises, interdisciplinary comprehensive practical activities are not limited to the classroom, with flexible locations and diverse themes, which can better stimulate students' enthusiasm. A good interdisciplinary comprehensive practical activity should have clear goals, distinct themes, and students' feasibility. The activity experience can effectively help students apply mathematics in their daily lives and stimulate their interest in learning.

4.4 Flexible use of Modern Information Technology to Assist Classroom Teaching

This strategy requires teachers, guided by teaching objectives and content, to reasonably use GeoGebra, Geometry Drawing Board, and other math teaching software to assist teaching and learning, to draw and dynamically transform geometric shapes, and to inter-convert numbers and shapes, etc. And to utilize emerging technologies, such as AR technology and ChatGPT for human-computer interaction teaching.

The most prominent feature of modern information technology is the intuitive display of geometry from a dynamic perspective, which is more widely used in the teaching of images and geometric knowledge [15,16]. At present, information technology equipment has been widely popularized in the vast majority of schools, but some teachers are unable to use reasonable technical support in conjunction with the course content. Mathematical abstraction requires the transformation of numbers and shapes and the presentation of spatial forms. Reasonable technical support can not only save teachers' time for manual drawing but also show dynamic transformations in space and help students visualize abstract thinking [17,18]. Moreover, Junior high school students have a strong preference for information products and have strong interpretive abilities in various forms such as images, videos, and audio.

Therefore, teachers should deepen the research on the application of informatization teaching means to build a diversified classroom [19].

5. CONCLUSION

Since the introduction of mathematics key competencies, mathematics education has gradually shifted from a ‘knowledge-based’ to a ‘literacy-based’ approach [2]. Abstraction ability is one of the manifestations of core literacies, and the classroom is the main battlefield of subject

teaching. Teachers must adopt effective strategies to cultivate students' abstraction ability in classroom teaching. This paper provides an in-depth analysis of the definition and requirements of abstraction ability in the new curriculum standards. Combined with the current situation of classroom teaching, it is believed that to implement the cultivation of abstract ability literacy in classroom teaching, teachers should combine problem scenarios to allow students to experience the process of generating mathematical knowledge; Carefully design exercise questions, conduct isomorphic and variant training, and strictly regulate mathematical language expression; Organize interdisciplinary comprehensive practical activities centered on mathematics; Flexibly utilizing modern information technology to assist classroom teaching.

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Authors have declared that no competing interests exist.

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