



# **Research on the Implementation of Space Concept Literacy in the Junior High School Mathematics Classroom Teaching in China**

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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**

Current junior high school mathematics classrooms are increasingly focusing on the implementation of mathematics core literacy in China. Space concept literacy is one of the core literacy, so its implementation is attracting much attention. Based on clarifying the connotation and requirements of space concept literacy in the *Mathematics Curriculum Standards for Compulsory Education (2022 Edition)*, and analyzing the highlights and deficiencies of junior high school mathematics classroom teaching, this paper puts forward four strategies for the implementation of space concept literacy in the classrooms: 1. designing life-related geometric inquiry activities with clear programs; 2. making reasonable use of objects and models; 3. adding measurement, graphing, manipulation into the teaching process; 4. flexibly using

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mathematics teaching software and emerging technologies to assist teaching. It is hoped that these strategies can provide ideas for the better development of junior high school mathematics teaching.

**Keywords:** Junior high school mathematics; curriculum standards; space concept literacy; teaching strategies.

## 1. INTRODUCTION

The *Mathematics Curriculum Standards for Compulsory Education (2022 Edition)* (hereinafter referred to as the *Standards*) clearly states that space concept literacy is one of the main manifestations of core literacy in junior high school mathematics, which helps students to understand the knowledge related to space and figures and accumulates experience to form spatial imagination. It is the basis for the development of intuitive imagination literacy at the stage of senior high school [1]. Therefore, the research on space concept literacy has become a hot topic in education research today. What are the connotation and requirements of space concept literacy? What is the current situation of junior high school mathematics classroom teaching? What strategies should be adopted to implement space concept literacy in the classrooms? This paper will analyze the above issues.

## 2. LITERATURE REVIEW

In the past two decades, many scholars have studied space concept literacy in junior high school, and by combing through the literature, it is found that the main research directions are the following five aspects: dimensional division, influencing factors, development status, cultivation strategies, and curriculum resource. Among them, the research on the development status and cultivation strategies of junior high school students' space concept literacy is relatively rich, but few studies interpret the connotation and requirements of space concept literacy in the *Standards* and analyze the measures to implement this literacy in the mathematics classroom teaching accordingly. Therefore, this paper will conduct this aspect of research.

## 3. CONNOTATION AND REQUIREMENTS

The *Standards* points out that space concept literacy connotes the cognition of the shape, size, and positional relationships of objects or figures [1]. The requirements for junior high school students are as follows:

### 3.1 Be Able to Abstract Geometric Figures Based on the Characteristics of Objects and Visualize the Actual Objects Described Based on the Geometric Figures

Objects refer to three-dimensional objects in the real world, whose characteristics mainly include shape, size, structure, and constituent elements. Abstraction refers to the formation of a spatial representation in the mind based on the objective characteristics of an object, and giving a visual representation with a plane figure [2]. The requirement expects students to be able to form a spatial representation of a three-dimensional object based on its shape, size, structure, constituent elements, etc., to make a mental geometric figure, and to be able to use the properties of the geometric figure to visualize and describe the geometric features of a three-dimensional object.

### 3.2 Be Able to Visualize and Express the Spatial Orientation of Objects and Positional Relationships between Them

The spatial orientation of an object refers to the position that a three-dimensional object occupies in space and the spatial inter-positional relationships with other objects around it. The requirement expects students to be able to form mental representations of an object's position in space and of the positional relationships between different objects, to express the positional relationships of plane figures formed from the representations in terms of lengths and angles in plane geometry, and to establish the connection between three-dimensional space and plane figures.

### 3.3 Be able to Perceive and Describe the Patterns of Graphic Motion and Change

Graphic change mainly includes three basic types of graphic motion (axisymmetric, rotation, and translation), graphic similarity, graphic projection, etc. The patterns of graphic change

refer to the patterns of change or invariance of the positional relations and metric properties of figures in graphic change [2]. Perception includes the sensory process and the perceptual process. The sensory process is that the human brain perceives certain characteristics of the graphic change, and the perceptual process is that the perceived information is processed and understood, and ultimately forms the understanding of the change patterns or invariance, and expresses them [3,4]. The requirement expects students to be able to feel and cognize the patterns of change and invariance of positional relationships and measurement properties of figures in the process of change, and to express them in mathematical language.

#### **4. THE CURRENT SITUATION OF MATHEMATICS CLASSROOM TEACHING**

1. In the teaching content: teachers focus on the explanation of graphics and geometry knowledge, and lack the cultivation of logical reasoning ability [5]. Students need to cultivate a more rational space concept literacy in junior high school, but the current mathematics classroom teaching is still based on the direct transmission of knowledge, neglecting the training of students' logical reasoning ability.
2. In the teaching mode: although teachers have improved the disadvantages of indoctrination teaching and added inquiry activities or group discussions, there are problems with poorly designed instructional activities, focusing on the explanation of the answers and neglecting the guidance of the exploration process. Some teachers do not have clear teaching objectives and indulge students in discussions, leading to inefficiency in the classrooms [6].
3. In the instruction means: teachers generally use modern information technology to assist in geometry teaching, but there are several problems of inappropriate use. One is that some teachers do not have enough preparation before class, and only show pre-made or simple images or animations that students have already known in class, so they are unable to flexibly utilize the technology according to the actual classroom situation; the second is that some teachers misuse

multimedia, lack the necessary blackboard writing, and arbitrarily use poor-quality Internet resources [7].

4. In the classroom status: teachers are dominant in classroom activities, and students are passively engaged. To better control the teaching order, some teachers often substitute teaching for learning and guide students' thinking to the content scheduled by teachers. It seems that they attach importance to mathematical thinking, but in fact, they deprive students of the opportunity to think [8].
5. In the classroom interaction: the classroom is dominated by teacher-student interaction, and students rarely interact with each other. In the teacher-student interaction, teachers usually put forward closed questions, and then students give answers, which is a meaningless formal interaction [9]. It lacks the purpose of deepening students' understanding and mastery of key teaching contents, and it is difficult to inspire students' thinking.

#### **5. STRATEGIES**

To truly implement space concept literacy in junior high school mathematics classrooms and improve bad teaching behaviors in current classroom teaching, teachers are recommended to adopt the following strategies.

##### **5.1 Designing Geometric Inquiry Activities with Clear Programs Related to Real Life**

This strategy explains that teachers are required to design inquiry-based learning activities in the area of graphics and geometry from the reality of students' lives, based on mastering the teaching contents and objectives, with the explicit research object, research problem, research direction, and methodological steps [10].

Geometric inquiry activities are an important way to learn graphics and geometry knowledge, as well as an important way to improve space concept literacy [11-13]. The real world has objects of all shapes and sizes, and there are different positional relationships and changing states between objects, so designing geometric inquiry activities from life situations can help students abstract geometric figures from actual objects, master the concepts and properties of

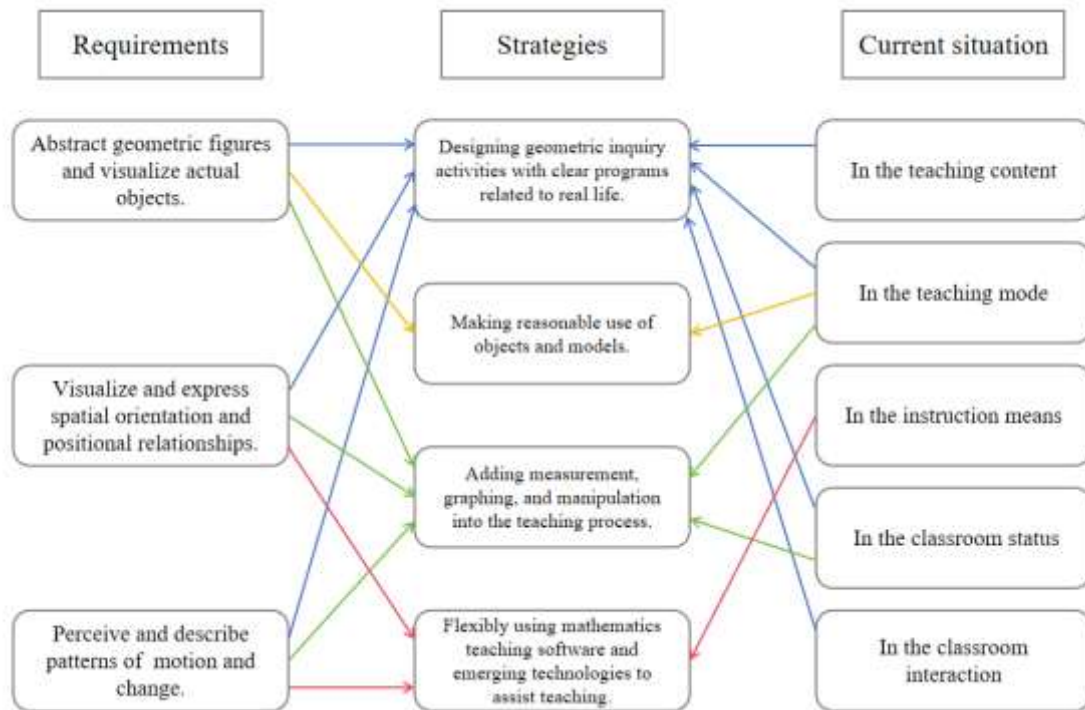


Fig. 1. Inference process diagram

geometric figures, feel the transition from the spatial orientation of objects to the positional relationship of plane shapes, as well as perceive the change and invariance in the process of graphics motion and change from the rich examples of life.

Good geometric inquiry activities can enhance students' space concept literacy based on grasping basic knowledge, basic skills, basic ideas, and basic activity experience, train students' logical thinking, give students the initiative to learn, and improve the quality of teacher-student interaction and student-student interaction.

## 5.2 Making Reasonable Use of Objects and Models

This strategy explains that teachers are required to use the practical objects that students are familiar with in real life or use the models and teaching aids matched with the textbooks to teach in the area of graphics and geometry.

The visual objects and models can help students understand the abstract geometric knowledge, deepen students' overall grasp of the characteristics of space objects, and guide students to establish the connection between

two-dimensional graphics and three-dimensional world. Students discover and understand geometric bodies, planes, lines, points, and other concepts by observing objects and models, and complete the abstraction from objects to figures, and from figures to objects.

Reasonable use of objects and models can effectively help students correctly understand abstract problems in geometry learning, make geometry learning simpler and more efficient, improve the quality of teaching, and stimulate learning interest.

## 5.3 Adding Measurement, Graphing, and Manipulation into the Teaching Process

This strategy explains that teachers are required to guide students to carry out measurement activities such as measuring the lengths, angles, areas, and volumes of figures according to the teaching objectives and contents, to carry out graphing activities such as drawing different geometric figures and their variations with teaching tools such as rulers and compasses, and to carry out manipulation activities to gain perceptual experience and understand geometric concepts through hands-on practice by utilizing certain manipulatives and physical materials.

Through measurement, students can get some visual characteristics of geometry, nature, and positional relationships. Through graphing, students can be familiar with the principles and steps of ruler and compass construction and further understand the properties, theorems, and changing characteristics of geometric figures. Besides, students will be able to reinforce the connection between three-dimensional space and planar figures through hands-on manipulation.

Through specific measurement, graphing, and manipulation, students can further understand three-dimensional space and graphics, and cultivate a sense of space. Understanding of three-dimensional space is an important expression of space concept literacy [2]. Therefore, the above teaching links are conducive to the formation and development of space concept literacy and can attract students to actively participate in classroom activities.

#### **5.4 Flexibly Using Mathematics Teaching Software and Emerging Technologies to Assist Teaching**

This strategy explains that teachers are required to use mathematics teaching software such as GeoGebra, Mathstudio, Maple, MATLAB, Python, etc. to assist teaching, to draw and dynamically transform geometric figures, to convert numbers and shapes, and to display complex geometries; and to use AR technology, ChatGPT, and other emerging technologies for human-computer interaction teaching.

The most powerful function of modern information technology for geometry teaching is the graphic visualization, and dynamic display, which can make up for the lack of physical objects and the blackboard writing and show the complexity of the spatial orientation of objects and changes in motion. Through the aid of technology, students can better imagine and express the positional relationship between objects and the patterns of change. At the same time, students will be able to more easily use the plane rectangular coordinate system to understand geometric properties, features, relationships, etc.

Borrowing the excellent performance of modern information technology, junior high school mathematics classrooms can create a more efficient, open, innovative, and diversified teaching environment for students [14], enrich students' experience in the field of graphics and

geometry, and comprehensively improve space concept literacy.

## **6. CONCLUSION**

The *Standards* emphasizes that teachers should teach with the orientation of mathematics core literacy [1], therefore, appropriate teaching strategies can be adopted to achieve the real implementation of core literacy. In this paper, based on an in-depth analysis of the connotation and requirements of space concept literacy, combined with the current status of mathematics classroom teaching, it is believed that to achieve the implementation of space concept literacy, teachers must design geometric inquiry activities with clear programs related to real life, make reasonable use of objects and models, add measurement, graphing, manipulation into the teaching process, flexibly use mathematics teaching software and emerging technologies to assist teaching.

## **7. FUTURE ENHANCEMENTS**

Junior high school mathematics teachers' literacy level is a key factor in deepening the implementation of space concept literacy, so it is necessary to promote the professional development of teachers while enhancing students' space concept literacy. How to strengthen teachers' internalization of space concept literacy and improve the teaching ability directed by core literacy will be an issue that needs to be further explored. It is suggested that future research could focus on teachers' mastery and use of space concept literacy, explore the relationship between teachers' literacy levels and students' literacy levels, and then suggest strategies for teachers' improvement.

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## **COMPETING INTERESTS**

Authors have declared that no competing interests exist.

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