



# Examining the Integration of Model Concept Literacy in Mathematics Instruction for Junior High School Students

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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**

Compulsory Education Mathematics Curriculum Standards [1] emphasizes the core literacy of model concept, and there are many current studies around model concept, but there are few analyses aimed at the implementation of the model concept literacy of the junior high school mathematics curriculum standard in the junior high school mathematics classroom teaching, so this paper analyzes the feasibility of and strategies for the implementation of the model concept based on the connotation of the model concept and the current status quo of junior high school mathematics teaching. Teachers can take the form of collective lesson planning to strengthen the understanding of the connotation of the model concept; introduce the materials related to mathematical learning that occurs in real life into the classroom promptly, and show them to students in the classroom in a contextual way; explain the process of mathematical modeling, knowledge points, analytical ideas, and other basic knowledge, and use a variety of teaching methods such as inspirational, discursive, exploratory, and practical, to create a relaxed and free

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learning atmosphere; promote students' mastery of equations, inequalities, functions, and other knowledge, creating opportunities to cultivate model concept literacy, consciously carrying out practical teaching activities, improving the ability to use mathematical models to solve problems, etc., to be able to truly implement the model concept in the classroom.

*Keywords: Model concept; junior high school mathematics classroom teaching; implementation strategies.*

## 1. INTRODUCTION

The Mathematics Curriculum Standard for Compulsory Education [1] proposes that the mathematics curriculum should cultivate students' core literacy, which consists of three aspects, i.e., the "three pieces of knowledge", which are mainly manifested in nine aspects in the junior secondary school stage of compulsory education, and gradually strengthens the connection between mathematics and real-life (2022). The concept of modeling is one of the nine core literacies proposed in the Curriculum Standards, which requires students to be able to connect with real life by building mathematical models. With the changes in the requirements of the curriculum standards, mathematics, and life are more and more closely linked, so it is particularly important to cultivate students' ability to be able to connect mathematical knowledge and real life, that is, the implementation of the model concept literacy is very necessary [2-4]. So what is the connotation of the concept of modeling and the requirements put forward in the Curriculum Standards? What is the current situation of junior high school mathematics teaching? Is it feasible to implement the concept of modeling in junior high school mathematics classroom teaching? How to implement the concept of modeling in junior high school mathematics classroom teaching? This paper will discuss the above questions.

## 2. THE CONNOTATIONS OF MODEL CONCEPT AND THE REQUIREMENTS FOR ACHIEVING IT

### 2.1 Connotations of Model Concept

The Mathematics Curriculum Standards for Compulsory Education [1] states that the concept of modeling mainly refers to having a clear understanding of the use of mathematical models to solve practical problems (2022).

Application, refers to the use of things according to their characteristics; mathematical model, refers to the use of mathematical logic and

mathematical language to establish a model for solving practical problems; solution, refers to the sorting out of the clear, dealing with the results; practical problems, refers to real problems, that is real problems in the real world, which is the difference between mathematical exercises is more real, closer to life; clarity, refers to the things can be clearly understood; awareness, refers to cognitive knowledge, is the human brain to reflect the characteristics and connections of objective things, and expose the meaning and role of things for people thinking activities, including all cognitive activities, such as memory, imagination, language comprehension, and other psychological phenome, in a narrow sense, awareness is sometimes equivalent to memory or thinking.

Thus, the concept of modeling refers to the ability of students to have a clear understanding of and think about the use of mathematical knowledge to solve real-life related problems using models built up using mathematical logic methods and mathematical language.

### 2.2 Requirements for Reaching Model Concept

The Curriculum Standards set out clear requirements for the standards that students should meet about the concept of modeling:

- (1) Know that mathematical modeling is a fundamental way to connect mathematics to reality.

Reality refers to the objective existence of things or facts; connection refers to contact, but also refers to the organic connection between things; the basic way, refers to the most basic channels, the basic way is generally the simplest way to lay the foundation for the behavior of the later.

Therefore, the first requirement put forward by the Curriculum Standard explains that mathematical modeling is the most basic and simple way and method that can connect mathematics with reality, which affirms the role of

mathematical modeling, and at the same time puts forward the requirement for students to learn and know the important role of mathematical modeling.

- (2) Initial perception of the basic process of mathematical modeling and abstraction of mathematical problems from real-life or concrete situations.

Preliminary, generally refers to the beginning stage; perception, i.e., a series of processes in which the consciousness perceives, feels, pays attention to, and knows the internal and external information; therefore, preliminary perception, i.e., the process of starting to let the consciousness perceive and feel the internal and external information, is still in the beginning stage, and it is still an imperfect, incomplete perception; the basic process is the most basic process, referring to the most basic procedures through which things are carried out or things are developed; real life, that is, the actual existence of the current living conditions and objective things; situation, refers to the combination of various situations at a certain time, including the drama situation, the living situation, the teaching situation, the social situation, the learning situation, etc. Abstraction is the process of abstracting from the common, essential features of a large number of things and discarding the non-essential features of the process. Reflect the nature of things and the law of the method revealed; the abstraction of mathematical problems: that is, from the real situation, reveal the mathematical nature or equivalence of the relationship, discard the non-essential problems of the scenario, transformed into a symbolic representation of the mathematical problem.

Therefore, the second requirement of the Curriculum Standards for the concept of modeling is to let the students, at the beginning stage of contact with models, first perceive the most basic process of modeling to solve problems with awareness, and then learn to extract the essence of the problem and the mathematical problem to be solved from the specific life situation problems, that is, to find the most essential features of the problem.

- (3) Use mathematical symbols to create equations, inequalities, and functions to represent quantitative relationships and patterns of change in mathematical problems, to find the results, and to discuss the significance of the results.

Mathematical symbols refer to the product of human rational thinking and abstract thinking, including quantitative symbols, operational symbols, relational symbols, etc.; quantitative relationship, refers to the number and the middle of the number, the number and the middle of the unknown number, the unknown number and the unknown number of the equal amount of the size of the relationship between; law refers to the relationship between the things summarized through the observation of the phenomenon; law of change, the change of the phenomenon is the study of the change of this kind of relationship between the phenomena The result refers to a state of things or the purpose or goal achieved; to find out the result means to achieve the final goal with the help of methods and means; to discuss the significance of the result, and to subjectively analyze, judge, and interpret the result.

Therefore, the third requirement of the Curriculum Standards for the concept of modeling is that for the quantitative relationships, patterns of change, and the essential features of the problem that have been extracted from the mathematical problem, based on the knowledge points of equations, inequalities, functions, etc. that have already been learned, the mathematical symbols such as the quantitative symbols and the operation symbols are used to represent them, to further derive the results, and to analyze the significance of the results obtained in the practical context.

### **3. ANALYSIS OF THE CURRENT SITUATION OF MATHEMATICS TEACHING IN JUNIOR HIGH SCHOOLS**

#### **3.1 Insufficient Attention to the Model Concept by Teachers or Students**

Lei Yehong et al. [5] analyzed the example problems in the article through the literature analysis method, combined with the front-line teaching experience, and found the existence of students' insufficient attention to knowledge and easy to be affected by the stereotyped thinking of junior high school students in the aspect of the model idea; Miao Xingqiao [6] found out that the model idea was seldom mentioned by the teachers in the classroom using questionnaires and tests on the students, as well as interviews with the teachers, and that the majority of the teachers would create situations in the classroom, and junior high school mathematics teachers can

realize that model thinking and contextual teaching are important for students' mathematics learning and future development;

Mathematics teaching in junior high school is still dominated by traditional indoctrination, the classroom time is short, and the content is relatively complex and tedious, so the transfer of knowledge in the classroom occupies more time in the classroom, so it is difficult for teachers to take into account the integration of real-world problems into the classroom teaching in the process of teaching, and the teachers pay most attention to problem-solving, and pay less attention to the cultivation of the ability to think and ask questions, and the students, as the passive recipients of learning, have less understanding of the concept of modeling, and even close to half of the students have never heard of modeling [7], now teachers are slowly beginning to pay attention to the introduction of the real situation, and also realize the importance of the model idea, but forced by the pressure of some realities, there is still a lack of infiltration of the model idea in the classroom teaching.

### **3.2 Lack of Clarity in Understanding of Model Concept**

Xu Ronghua [8] found that the current classroom penetration of mathematical model concept has the following problems: firstly, teachers only explain example problems and do not inform students of the process of constructing models and building ideas, secondly, students do not know how to build model ideas, thirdly, model construction is not in-depth and model ideas are not built in a proper way, which is often confined to a lower level; Yao Hanyun [9] through questionnaire surveys and interviews, found that students and teachers do not have a thorough understanding of modeling ideas, teachers lack research on the integration of modeling ideas into mathematics teaching, and there is a lack of introduction and application of modeling ideas in actual teaching.

Junior high school mathematics classroom is often knowledge-based, by the influence of exam-oriented education, teachers pay more attention to the results of the students to solve problems, for the problem-solving process and students to think is relatively neglected, so the teacher's understanding of the concept of the model is not very clear, and the degree of attention is not enough, often at a lower level,

which leads to the students for the concept of the model is a half-knowledge, can't be flexible and skilled application of the concept of the model in the process of problem-solving process.

### **3.3 Weak Ability to Apply Model Concept**

Wang Lu [10] used questionnaires and interviews to investigate the current status of students' and teachers' model concept, more than half of the students said that they could not transform natural language into mathematical language, which indicated that some students did not form model concept; Liao Yaqian [11] used questionnaires to investigate the concepts of mathematical model ideas, mathematical models in life, mathematical models in the classroom learning and the application of these four aspects of the school's eighth-grade students do not know much about the mathematical model idea, the understanding of mathematical models is not deep enough, and very few students will use the mathematical knowledge they have learned to solve the problems they encounter in daily life; Li Qi [12] investigated the current situation of the teaching of mathematical model idea in junior high school by means of a questionnaire survey and an interview, and found that most of the students like mathematics, but the students' ability of applying the model idea is is not high, especially for real problems, it is difficult to solve them by building mathematical models.

Most students can recognize the usefulness of mathematics in the process of learning mathematics, and most students can recognize that the concept of mathematical models reflects the connection between mathematics and reality, and agree that learning the concept of models is helpful for learning and life, but the concept of mathematical models in junior high school mathematics teaching exists in the teaching of the traditional, the teaching system is not flexible enough, the students to understand the difficulty, and the reality of the teaching of the more dispersed, the model of the concept of linking reality is not close enough to practice, so the students' concept of model is relatively weak. However, the teaching of model concept in junior high school is traditional, the teaching system is not flexible enough, it is difficult for students to understand, and the teaching is scattered in reality, the model concept is not closely related to reality, and there is a lack of concrete problem materials for practice, so students' model concept is relatively weak.

### 3.4 Biased Motivation for Learning Models

Fang Xiuquan [13] pointed out that in the integration of modeling ideas into junior high school mathematics teaching, students' understanding of mathematical modeling ideas is too one-sided, and they think that they are only used for daily problem-solving, and the application of mathematical modeling ideas is too passive; Huo Xiaoli [14] used questionnaires and interviews to investigate junior high school student's interest in mathematics learning and motivation to learn, and the majority of the students were able to learn about the model concept through the teaching process of their teachers. Most of the students are satisfied with teachers' teaching methods and approaches and believe that mathematical modeling ideas are useful and can be applied to solve problems in practical problem-solving.

Teachers generally have their own pedagogical thinking and teaching methods for teaching mathematical modeling, but students, more often than not, think that the role of mathematical modeling is to cope with exams, and only a small number of students are interested in learning models, as the motivation of students to learn models is not out of intrinsic interest, and the bias of motivation, therefore, leads to the possibility that students may not be very active in learning.

## 4. FEASIBILITY ANALYSIS OF IMPLEMENTING THE MODEL CONCEPT IN JUNIOR HIGH SCHOOL MATHEMATICS CLASSROOM TEACHING

Since the Compulsory Education Mathematics Curriculum Standard [1] stipulates the comprehensive development of core literacy for secondary school students, the nine core literacy has become a buzzword in the mouths of educators for a while, setting off a fervor for the comprehensive implementation of core literacy for primary and secondary school students. Cultivating core literacy talents is a major trend of social development and social participation in the cultivation, which can provide a large educational environment for the implementation of the model concept.

By analyzing the questions of the Chinese junior high school Examination in recent years, it is easy to see that the number of questions on mathematics and real life is gradually increasing,

and the number of questions that simply test the basic knowledge of mathematics is getting smaller and smaller, so it is necessary for students to improve their ability to understand and apply mathematics. At present, teaching in junior high school is still oriented to the questions of the midterm examination, so the increasing importance of the application of mathematics in the questions of the midterm examination will inevitably attract the attention of front-line teachers, to improve their ability to model concept, and then teach students the process of model thinking and application.

By cultivating the concept of modeling, teachers use mathematical language to convey life problem-solving methods to students, which is a logical and meticulous process that is conducive to the development of students' thinking ability and the concept of modeling, whereas in traditional teaching, teachers explain the background of the knowledge and the scope of application, which is time-consuming and labor-intensive, resulting in the classroom not being sufficiently compact, and the students being confused about the content. When the concept of modeling penetrates the classroom, it is not only conducive to increasing students' interest but also facilitates students' concentration and achieves the desired teaching effect.

Cultivating the concept of modeling not only emphasizes the mastery of basic knowledge but also the cultivation of innovative and practical abilities. On the premise of students' mastery of basic knowledge, teachers introduce specific scenarios to solve practical problems. The model concept emphasizes the ability of students to explore independently. The penetration of the model concept will also focus on the diversification of the evaluation, focusing on both the evaluation of the final problem results and the evaluation of the model-building process, focusing on both the student's academic performance and the non-intellectual factors such as the attitudes shown in the process of building the model. It greatly enriches the scope and manner of evaluation.

The cultivation of model concept is based on mathematical knowledge and practical background, so for students with poor mathematical foundations and no interest in learning, teaching in practical situations can attract their attention. In the traditional teaching mode, especially when teaching some difficult-to-understand knowledge points, no matter how

carefully the teacher explains them in class, not many students can understand them, and the homework after class has the characteristic of fixed answers, which leads to the phenomenon of students copying each other's homework, so it is difficult for students to review and consolidate them in time, and they are bound to fall behind in their learning of mathematics in the long run. If the implementation of the model concept, the model for the solution of the topic is different from person to person, to seize this feature, students need to think independently, so that mathematical knowledge can be truly internalized into the student's knowledge system, and the collision of thinking between teachers and students and exchanges, but also the establishment of good teacher-student relations, the quality of teaching will be greatly improved.

## **5. STRATEGIES FOR IMPLEMENTING MODEL CONCEPT IN JUNIOR HIGH SCHOOL MATHEMATICS CLASSROOMS**

### **5.1 Teachers Adopt Group Lesson Planning to Enhance Students' Understanding of the Model Concept as the Use of Mathematical Models to Solve Real-world Problems**

Collective lesson preparation means that teachers' collective lesson preparation is a series of activities such as studying the syllabus and teaching materials collectively, analyzing the learning situation, formulating teaching plans for the subject, decomposing the tasks of lesson preparation, finalizing the teaching design, and feeding back the information on teaching practice, etc. in the form of a lesson preparation group; enhancement means to strengthen, to make stronger and more effective; cognition refers to the cognitive knowledge, which is the thinking activity of the human brain to reflect the characteristics and connections of the objective things and to expose the meaning and effect of things on the human being. human meaning and role of thinking activities, including all cognitive activities of human beings, such as memory, imagination, understanding of language, and other mental phenomena, in a narrow sense, awareness is sometimes equated with memory or thinking. "To give students a glass of water, you need to have a bucket of water yourself." To improve students' concept of modeling, teachers can first learn from each other's knowledge and experience through collective learning and

lesson planning, and improve their knowledge of the definition of modeling, "the use of mathematical models to solve real-world problems", so that they can be more skillful in teaching and imparting relevant knowledge.

The Curriculum Standards indicate that the concept of modeling is a clear understanding of the use of mathematical models to solve real-world problems. The source of students' knowledge is not only independent learning but also needs to be taught by teachers, so teachers need to strengthen the learning and discussion of model concept classroom cultivation strategies. For the connotation of the model concept of understanding, some teachers have unclear knowledge of the status quo, so you can take the collective learning and lesson planning, discuss the teaching content that can penetrate the model concept, improve their level of model concept, and promote the teachers' knowledge of the core literacy, to promote the students' understanding of the model concept, and better use of the model concept to solve real-world problems.

### **5.2 To Introduce Materials Related to Mathematics Learning that Occur in Real Life into the Classroom Promptly, the Content of the Textbook Should be Presented to Students in the Classroom in a Contextualized Way through Familiar Examples from Life**

Real life, that is to say, the current actual existence of the living conditions and objective things; collected, unorganized and processed, perceptual, dispersed raw materials; contextually, it means that the mathematical problem is given set as a large environmental background, and then in this context to the students to illustrate the occurrence of the process of development and the discovery of the existence of the problem, and together in the context of the existence of the problem perceived.

The Curriculum Standards require students to know that mathematical modeling is a fundamental way of connecting mathematics to reality. Cultivating the core literacy of students' concept of modeling requires that students be clear about what mathematical modeling is, and some students may know about it, but their knowledge is incomplete or biased so they are not clear about mathematical modeling. Therefore, teachers need to introduce materials

related to mathematical learning that occur in real life into the classroom promptly, and they should present the contents of the textbook to students using familiar instances in their lives in a contextualized way in the classroom. The creation of the scenario should be combined with the actual social life and other factors related to math problems so that students feel real, novel, interesting, and operable, and to meet the psychological requirements of students' curiosity and mobility. This will easily stimulate students' interest and activate the existing life experience in students' minds and also make it easy for students to use their accumulated experience to feel the mathematical problems implied therein, transform abstract mathematical ideas into concrete life examples, and perceive the existence of mathematical models more accurately. Let students understand the learning of mathematical modeling and grasp what the process of mathematical modeling is so that they can learn that mathematical modeling can connect the mathematical knowledge they have learned with real problems and better solve practical problems. And only after understanding the role of mathematical modeling, students will be more active in learning and exploring related knowledge.

### **5.3 Teachers Explain the Process of Mathematical Models, Knowledge Points, Analytical Ideas, and Other Basic Knowledge, using a Variety of Teaching Methods Such as Inspiration, Discussion, Exploration, Practice, and so on, to Create a Relaxed and Free Learning Atmosphere, Mobilize the Enthusiasm and Initiative of Students to Learn**

Basic knowledge is the knowledge that serves as the foundation of a certain field, from which the rest of the knowledge is derived; teaching method refers to the teaching means, strategies, and methods used by teachers in the teaching process, which is an important means of achieving the educational goals; creating an atmosphere refers to the creation of a specific environment in which people experience and enjoy things; and mobilizing motivation refers to the ability of students to be proactive and enterprising. To develop students' core literacy in the concept of modeling, teachers should first introduce students to the process of mathematical modeling, knowledge points, analytical ideas, and other basic knowledge, so

that students can find problems in daily life and establish the connection between mathematics and problems.

The Curriculum Standards require students to be able to perceive the basic process of mathematical modeling and to abstract mathematical problems from real-life or concrete situations. The cultivation of model concept is carried out based on specific real-life problems, and problem-solving requires the use of existing mathematical knowledge, so teachers want to cultivate students' model concept in the classroom, and they should put forward strategies based on specific knowledge points. Teachers should teach students the relevant basic knowledge of mathematical modeling so that they know the basic process of building mathematical models to solve problems, know how to combine mathematical knowledge with real-life problems. Combine the mathematical knowledge with real problems, find the traces of mathematics in the problem scenarios, find the connection between the real problems and the mathematical models, discover the role of mathematical models in real problem solving, and use this as a pivot point to summarize the degree of suitability of various types of mathematical models for various types of real problems, and finally discover the practical value of mathematical modeling and explore the path of its realization. After such training, students will be able to independently find problems, raise questions, and solve problems. Teachers should pay attention to stimulating students' interest in learning and self-confidence, and cultivate their innovative spirit and practical ability. For example, when building the model of parabolic motion, you can connect with the knowledge of quadratic function by depicting the trajectory of the motion, digging mathematical materials, and constructing the mathematical model of life.

### **5.4 Promote Students' Mastery of Equations, Inequalities, Functions, Etc., Create Opportunities to Develop Model Concept Literacy, and Consciously Carry Out Practical Teaching Activities to Improve the Ability to Use Mathematical Models to Solve Problems**

Mastery means knowing things and applying them fully; awareness means that the teacher can actively try to create opportunities to develop model concept literacy; and problem-solving

means the thinking process of searching in the problem space to bring the initial state of the problem to the target state. Knowledge of equations, inequalities, functions, etc. is an important tool for establishing quantitative relationships between variables, and after mathematical models are abstracted from actual problems, students then apply the above knowledge to solve them. Therefore, it is important to urge students to have a firm grasp of the knowledge of equations, inequalities, functions, etc., to be able to be more fluent in solving problems, thus improving their ability to solve problems.

The Curriculum Standards require students to be able to use mathematical symbols to establish equations, inequalities, functions, etc., to represent quantitative relationships and patterns of change in mathematical problems, to find the results, and to discuss the significance of the results. Therefore, when teachers explain the knowledge related to equations, inequalities, functions, etc., they allow students not only to learn mathematical theory, but also to apply theoretical knowledge independently to solve real-life problems and guide students to think about life problems that can be solved by these points of knowledge, to help students closely link this knowledge with their lives, and to help them understand the practical significance of mathematical modeling.

## 6. CONCLUSION

The development of the concept of modeling is not only one of the core literacies required of students by the Curriculum Standards but also an essential future development competency for teachers and students. Although there are still some problems in traditional teaching and the implementation of the core literacy of model concept is still facing some difficulties, the implementation of model concept is a necessary ability for contemporary students to solve real problems, which not only develops students' abstract generalization and innovation ability, but also awakens the knowledge of the past, and the model concept helps to improve the efficiency of mathematical problem solving, which is an effective way to improve the quality of junior high school mathematical teaching and improve the quality of students' mathematical learning, which can make students' mathematical activities more organized. It is an effective way to improve the quality of junior high school mathematics teaching and improve the quality of students'

mathematics learning, which can make students' mathematical activities more organized, and for teachers, it can prompt the professional knowledge of mathematics teachers to be constantly updated, so it is of great significance to implement the concept of model in junior high school classrooms. To truly implement the model concept, we still need teachers to continue to learn, explore, and find new ideas and strategies to promote the model concept, and to promote the development of students' mathematical level and problem-solving ability through the implementation of the model concept.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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