ISSN 2663-8169 Vol. 7, Issue 5: 51-55, DOI: 10.25236/IJNDE.2025.070508

Research on the Teaching of Quadratic Functions in Junior High School Mathematics under the 5E Teaching Model

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Abstract: *The new curriculum reform has put forward more new requirements for the teaching of junior high school mathematics in the classroom, and a variety of advanced teaching concepts, teaching modes and teaching methods have emerged in the field of secondary school teaching, aiming to achieve the classroom goals of paying attention to student development, emphasizing teacher growth, and teaching by learning. Among them, the 5E teaching model, as a new teaching model, can effectively promote the transformation of traditional classrooms into "student-centered" classrooms. Taking the quadratic function of Beijing Normal University as an example, this paper discusses how to design junior high school mathematics teaching based on deep learning theory and 5E teaching mode as the carrier, so as to help students improve their deep learning ability and improve their learning thinking ability.*

Keywords: *5E Teaching Mode, Deep Learning, Quadratic Functions*

1. Introduction

Quadratic functions occupy a core position in junior high school mathematics, which is not only a natural extension of primary functions, but also the cornerstone of future high school learning. It connects middle school and high school mathematics knowledge and supports students' in-depth understanding of the properties of functions. At present, it is very important to strengthen the practice of mathematics core literacy, and the teaching of quadratic functions needs to be adjusted according to the needs of students. Teaching should be more challenging and inspiring, stimulating students' interest and ensuring a comprehensive understanding of quadratic functions. In addition to imparting knowledge points, it is also necessary to focus on cultivating core literacy such as mathematical modeling, logical reasoning, and mathematical abstraction, so it is particularly urgent for the 5E teaching model to guide students to experience the application of quadratic function knowledge, cultivate problem-solving ability, and achieve in-depth understanding of knowledge.

2. Research Review

2.1 The 5E Teaching Model

The origins of the 5E teaching model can be traced back to a teaching strategy called "Learning Loop" developed by the Science Curriculum Improvement Research (SCIS) project in the United States. [1]The "Learning Loop" consists of three core components: initial inquiry, concept introduction, and concept application. Inspired by constructivist theory, Bybee [1]has distilled a model of five closely linked teaching steps: Engagement, Exploration, Explanation, Elaboration, and Evaluation.

In 2001, Bibbons highlighted eight key elements to focus on when using the 5E teaching model (five components of participation, inquiry, interpretation, transfer and evaluation) for inquiry-based teaching, each of which is designed to develop students' specific inquiry skills[2]. At the same time, the National Research Society of the United States also pointed out that the 5E teaching model can effectively enhance students' interactive communication and innovative thinking skills. After in-depth research, the results show that compared with the traditional education model, the 5E teaching model can significantly improve students' learning activity, depth of knowledge understanding and teamwork ability in classroom practice.

Yang Songyu (2023) combined deep learning with 5E teaching mode, designed a 5E teaching model based on deep learning, and applied it to high school mathematics classrooms[3]. Wu Junlin (2024)

ISSN 2663-8169 Vol. 7, Issue 5: 51-55, DOI: 10.25236/IJNDE.2025.070508

analyzed the relationship between the 5E teaching mode and deep learning, constructed the deep learning model under the 5E teaching mode, and analyzed that the combination of the two has a positive effect on improving students' interest and deepening classroom knowledge understanding[4].

2.2 Deep learning

In the 70s of the 20th century, Ference Marton and Roger Säljö of the University of Gothenburg in Sweden published a paper entitled "On the Qualitative Differences in Learning: I—Results and Processes" in the British Journal of Educational Psychology, which introduced the concept of deep learning for the first time. The study revealed that there were essential differences in learning outcomes and learning paths between the two groups. Specifically, the group of students who answered the questions directly showed a shallow level of processing of the content of the book, while the group of students who needed to summarize and reflect on the content showed an overall grasp and in-depth understanding of the text, reflecting a deeper level of learning and processing. Although the term "deep learning" is not directly used in the original text, the comparison between "shallow processing" and "deep processing" clearly distinguishes the learning levels of students.

In 2013, the American Research Council officially defined deep learning as: deep learning is a student's deep understanding of the fundamentals of the curriculum and the ability to apply this understanding to real-world problems and situations[5].

3. Theoretical Foundations

3.1 The connotation of the 5E Teaching Model

The 5E teaching model was developed by the Biological Sciences Curriculum Study (BSCS) in the United States and consists of five interconnected components: Engagement, Exploration, Explanation, Transfer, and Evaluation. The "Engagement" component aims to attract students' attention and stimulate their interest in learning and desire to explore by creating engaging and thought-provoking problem scenarios, allowing students to immerse themselves in the learning topic. In the "Exploration" stage, students independently engage in inquiry-based activities such as observation, experimentation, and investigation under the guidance of teachers, gaining direct experience and attempting to analyse and solve problems. The "Explanation" component requires students to use existing knowledge and evidence obtained during exploration to explain observed phenomena and develop scientific concepts. The "Transfer" component encourages students to apply new concepts in new situations, deepening their understanding of knowledge. "Evaluation" is integrated throughout the entire teaching process, where teachers assess students' learning processes and outcomes through various evaluative methods to understand their mastery of knowledge and levels of skill development.[6]

3.2 Theoretical Basis of the 5E Teaching Model

Constructivism holds that knowledge is not acquired through the teacher's imparting. Instead, learners obtain it through the way of meaning construction with the help of others and by making use of necessary learning materials within a certain situation, that is, the sociocultural background. Each component of the 5E teaching model fully reflects the principles of constructivism. In the inquiry phase, students actively engage in practical activities, constructing their understanding of knowledge through interaction with the environment; in the explanation phase, students integrate their experiences with new information to form personalised interpretations of knowledge and further enhance their knowledge system.

Bruner's discovery learning theory emphasizes that students should actively participate in the process of discovering knowledge and grasp the basic structure of the subject through independent inquiry and thinking. The inquiry and refinement stages of the 5E teaching model encourage students to explore and discover knowledge like scientists, fostering students' abilities for independent learning and innovative thinking, aligning with the theory of discovery learning.

3.3 The Relationship between the 5E Teaching Model and Deep Learning

Both the 5E teaching model and deep learning are fundamentally based on constructivist learning theory, emphasizing students' active participation and the process of knowledge construction. Additionally, both frameworks focus on students' independent inquiry and cognitive development, being

ISSN 2663-8169 Vol. 7, Issue 5: 51-55, DOI: 10.25236/IJNDE.2025.070508

influenced by discovery learning theory, contextual learning theory and metacognitive theory to some extent.Moreover, the ultimate goal of both the 5E teaching model and deep learning is to promote the comprehensive development of students, enhancing their learning capabilities and core competencies. The 5E teaching model provides opportunities and platforms for deep learning through systematic design of teaching stages; deep learning guides the implementation of the 5E teaching model by requiring the teaching process to pay greater attention to students' deep understanding and application of knowledge.

4. The teaching design principles of junior high school mathematics based on the "5E" teaching model

1) Teaching should be student-centered, and students should be guided to actively participate through the design of inquiry activities. Teachers should transform into the role of guides, focusing on cultivating students' problem-solving abilities and innovative thinking. The subjectivity of students should be implemented throughout the entire teaching process. Students should be encouraged to raise doubts, conduct cooperative inquiry, independently summarize, showcase their learning progress, and reflect on their learning. All these efforts aim to promote students' comprehensive development, embodying the concept of constructivism.

2) Teaching design should conform to students' cognitive laws and knowledge reserves. Relying on the logic of the "5E" model, it deepens the understanding of knowledge in stages. For example, in the expansion stage, variable and comprehensive questions are designed to gradually integrate new knowledge into the original cognitive system.

3) Implement the concept of the two-way connection between mathematics and life: In the introduction stage, create a real-life situation to stimulate students' interest and abstract mathematical problems; in the expansion stage, set up new situations to strengthen the application, enabling students to experience the practicality of knowledge and form a successful experience of combining learning with application.

5. Teaching design of 5E teaching mode based on deep learning in quadratic functions

1) Analysis of teaching materials

The content of this section comes from the content of the third section of the second chapter of the second volume of the ninth grade of junior high school mathematics of Beijing Normal University. The content of this section is another round of learning of functions after the eighth grade "primary function" and the ninth grade "inverse proportional function". In the junior high school three main functions (primary function, quadratic function, inverse proportional function), the quadratic function occupies an important position. As the opening section of the "quadratic function" application, this section plays the role of laying the foundation for the whole thing [7].

2) Analysis of the learning situation

Students have mastered the basic concepts of quadratic functions and quadratic equations, and can draw sketches of quadratic function images.

3) Analysis of major difficulties

[Focus]Understand the relationship between a quadratic equation and a quadratic function.

[Difficulty]The coordinates of the intersection of the parabola and any straight line will be found

Fourth.

4) The analysis of teaching objectives.

(a) Review the basic concepts and properties of quadratic functions through the teacher's guidance and students' recall.

(b) Understand the relationship between the quadratic equation and the quadratic function, be able to find the coordinates of the intersection of the parabola and the x-axis, and be able to judge the number of intersection points between the parabola and the x-axis.

5) Teaching methods

Teaching methods are intended to be lectures, demonstrations, independent inquiry, group

ISSN 2663-8169 Vol. 7, Issue 5: 51-55, DOI: 10.25236/IJNDE.2025.070508

cooperation and other methods.

6) Teaching process

(a) Create a situation and review and import

(b) Scenario import

Division: When the player hits the ball at a speed of 40 m/s in the direction of a 30° angle to the ground, the flight path of the ball is a parabola, and if the air resistance is not considered, there is a functional relationship between the flight altitude h (unit: m) and the flight time t (unit: s): $h=20t-5t^2$.

7) Consider the following questions:

(a) Can the ball fly at an altitude of 15 m? If so, how much flight time is required?

(b) Can the ball fly at an altitude of 20 m? If so, how much flight time is required?

[Design Intent]Using actual students or combined cases to stimulate students' interest in class and arouse students' curiosity about the knowledge of this lesson.

Question 1: Can the ball fly at an altitude of 15 m? If so, how much flight time is required?

Teacher: Equation $15 = 20t - 5t^2$ has two unequal real roots From the analytic formula $h = 20t - 5t^2$: when the independent variables t are equal to 1 and 3, the function value h is equal to 15. Conversely, when the function value h is equal to 15, the independent variables t are equal to 1 and 3.

[Design Intent]Osmosis equation thinking.

Question 2: Can the ball fly at an altitude of 20 m? If so, how much flight time is required?

Teacher: From the image of $h = 20t - 5t^2$, there is only one intersection point between the parabola $h = 20t - 5t^2$and the horizontal line h=20, and the abscissa of the intersection point is 2.

[Design Intent]The three questions we have here are all derived from the reality of life, which is very close to the daily life of students, which can stimulate students' interest in discovering and solving problems to the greatest extent.

8) Teaching of new courses:

(a) The parabola $y=ax^2+bx+c$ has two intersections[8] ↔

The unary quadratic equation for x ax^2+bx+c =0 has two unequal real roots.

(b) The parabola $y=ax^2+bx+c$ has an intersection ↔

The unary quadratic equation for x ax^2+bx+c =0 has two equal real roots.

(c) The parabola $y=ax^2+bx+c$ has no intersection ↔

The unary quadratic equation with respect to x ax^2+bx+c=0 has no real roots.

9) Explanation of examples

Example 1-1.The unary quadratic equation about x ax^2+bx+c=0:

(a) If the equation has two unequal real roots, then the intersection of the parabola $y=ax^2+bx+c$ and the x-axis is _____;

(b) If the equation has two equal real roots, then the intersection of the parabola $y=ax^2+bx+c$ and the x-axis is _____;

Example 1-2: Given that the parabola $y=x^2-bx+c$ intersects the x-axis at the points A(1,0),B(3,0), then the solution of the equation x^2-bx+c =0 for x is ( )

$A.x_1=-1,x_2=-3$ $B.x_1=-1,x_2=3$ $C.x_1=1,x_2=-3$ $D.x_1=1,x_2=3$

[Design Intent]Through a large number of example problems, students are guided to fully recognize and understand the relationship between quadratic function images and equations.

(c) Consolidation exercises

Exercise 1-1. For the quadratic function $y=ax^2-4x+2$, if its graph has two different intersections with the x-axis, what is the value of a?

ISSN 2663-8169 Vol. 7, Issue 5: 51-55, DOI: 10.25236/IJNDE.2025.070508

Exercise 1-2: If the parabola $y=x^2-2x-m$ has two intersections with the x-axis, what is the range of values of m?

(d) Classroom review and summary

The teacher guides the students to review the knowledge notes of the intersection of quadratic functions and equations and coordinate axes learned in this lesson, and asks students to explore the relationship between the two in a group cooperative learning way. Through review, students can deepen their memory of knowledge points, and at the same time develop their transfer ability to apply learning methods to other similar classrooms.

(e) After-school application and ability improvement

The teacher assigns homework and asks students to observe practical problems in life after class, look for examples that imply quadratic functions and real life, and share their findings in the next lesson.

[Teaching Evaluation]

This lesson introduces students through real-life situations and uses the review of the concept of quadratic functions to guide students to abstract, induct, and master the concepts of quadratic functions. Adopt the mode of teaching method, group cooperation and inquiry, respect the main position of students, integrate the cultivation of mathematical abstract ability, and complete the teaching objectives of the class.

6. Conclusions

The teaching design carried out in this paper is based on the theory of deep learning, integrates the 5E teaching mode, has novel forms and in-depth design problems, which is conducive to improving students' interest in mathematics inquiry, helping students to explore mathematics content in depth, improving their deep learning ability, and thus promoting the improvement of students' core literacy. This teaching design is in line with the three core concepts of student-centered, emphasizing teacher development, and promoting teaching through learning in the new curriculum reform, and opens up a new path for comprehensively improving students' spirit of inquiry and cooperation ability to a certain extent.

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