Cultivation Strategy of Senior Middle School Mathematics Classroom Teaching from the Perspective of Higher Order Thinking

Meiling Wang[a*] and Zhiqin Huang[b]

School of Mathematical Science, University of Jinan, Jinan, Shandong Province,China

[a]wangmeiling00ya@163.com, [b]hzq-1230@163.com

*corresponding author

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Abstract: In order to meet the society's requirements for high-quality talents and improve students' higher-order abilities, such as application ability, analytical ability, evaluation ability and innovation ability. This paper discusses the cultivation strategies of senior high school mathematics classroom teaching from the perspective of higher-order thinking. On the basis of analyzing the higher order thinking ability of mathematics, this paper puts forward the feasible training strategies from the four aspects of initial class, concept class, inquiry class and review class.

1. Introduction

With the rapid development of the era of education, social development has put forward higher requirements for the cultivation of high-quality talents in the future. Education should not only pay attention to the acquisition and accumulation of students' knowledge, but also pay attention to the comprehensive development of students' thinking ability and other core qualities, so as to improve the quality of students' thinking. In order to promote the development of students' thinking quality and implement the requirements of fostering virtue through education, the society and schools need to carry out in-depth teaching with higher-order thinking. Therefore, how to cultivate students' higher-order thinking and improve their higher-order thinking ability has become the top priority in classroom teaching.

According to the 2017 edition of Mathematics Curriculum Standards for Ordinary Senior High Schools, the goal of mathematics teaching in senior high schools is to develop students' core mathematical literacy. The development of higher-order thinking is an important way to realize the core accomplishment of mathematics and an inevitable trend of education reform. Combined with the requirements of the society for the cultivation of high-quality talents, it is urgent to put forward feasible cultivation strategies of senior high school mathematics classroom teaching from the perspective of higher-order thinking.

2. Higher-order Thinking

2.1. The Definition of the Concept of Higher-order Thinking

The study of higher-order thinking originated from the learning theory of Bloom and Gagne. Bloom stratified educational goals from the perspective of the cognitive domain. From high to low, there are six levels: evaluation, synthesis, analysis, application, understanding and knowledge. The first three are higher-order thinking ability and the last three are lower-order thinking ability[1]. But in 2001, Bloom's student Anderson and others revised Bloom's classification of educational goals. From the perspective of cognitive process, the educational goals are divided from low to high into memory, understanding, application, analysis, evaluation and creation. The first three are low-order thinking ability, and the last three are high-order thinking ability[2].

There are relatively few researches on higher-order thinking ability in China. Professor Zhixian Zhong believes that higher-order thinking ability is a kind of comprehensive ability occurring at a

higher level of cognition, which is a psychological feature of solving poor construction problems or complex tasks with higher-order thinking as the core [3]. In his opinion, compared with lower-order thinking, the characteristics of higher-order thinking can be understood as follows as shown in figure 1:

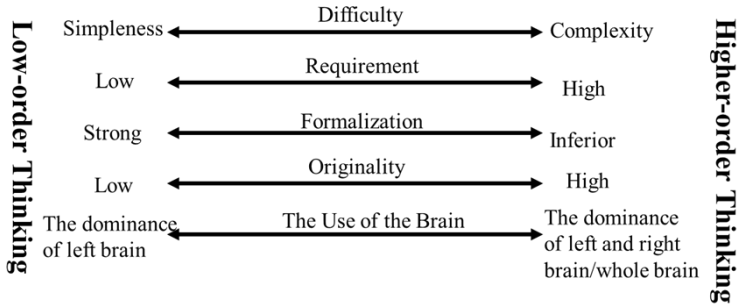

Figure 1. Characteristics of higher-order thinking

Based on the views of many scholars at home and abroad, it is found that most of them agree that higher-order thinking is a kind of ability mainly based on higher-level cognition, and individuals will carry out in-depth higher-level thinking activities when they encounter complex situations. Therefore, according to the definition of higher-order thinking by many scholars at home and abroad, this study defines higher-order thinking as four thinking levels in the cognitive system: analysis, knowledge application, evaluation and creation. Then, the corresponding extraction and understanding are lower-order thinking.

2.2. Mathematical Higher-order Thinking Ability

According to Bloom's cognitive target taxonomy, he think mathematics high-order thinking ability is refers to the students in mathematics learning activity in the process of higher cognitive level of level of cognitive ability, main show is application ability, analytical ability, ability and creation ability.

Among them, the application ability refers to the students choose and use a certain knowledge or method to solve unfamiliar problems. Analytical ability refers to the ability to reasonably decompose a mathematical concept or mathematical problem into a component and determine how to relate them. Evaluation ability refers to judging according to standards. Creative ability refers to the ability to discover and create new things.

Therefore, from the perspective of higher-order thinking, the cultivation strategy of high school students' mathematics teaching is mainly to cultivate their mathematical application ability, analytical ability, evaluation ability and creative ability. However, this does not mean that we do not pay attention to the memory, understanding and other lower-order mathematical thinking of high school students. Therefore, all the mathematics teaching strategies proposed in this study occurred after students' low-order mathematics thinking was improved, and they were in line with the development characteristics of high school students. Only in this way can we realize the development of students' mathematics low-order thinking and promote the development of their higher-order thinking, so as to realize the effectiveness of mathematics classroom teaching.

2.3. The Concepts Associated with Higher-order Thinking

As higher-order thinking, higher-order ability, higher-order learning and higher-order knowledge are closely related terms, many literatures often use each other, but in fact, they are still different.

High-order thinking refers to the mental activity or high-level cognitive ability occurring at a high cognitive level, which is manifested as analysis, synthesis, evaluation and creation in the classification of teaching objectives. Higher-order ability refers to the psychological characteristics of solving inferior structure problems or complex tasks with higher order thinking as the core, which combines the ability of developing higher order thinking, driving higher order learning and realizing knowledge transfer. Advanced learning refers to the use of higher-order thinking to carry out meaningful learning activities. High-order knowledge refers to the result of higher-order

learning, which is the necessary condition for realizing higher-order learning and developing higher-order thinking [4]. It can be seen that the relationship between the four is complementary, as shown in figure 2:

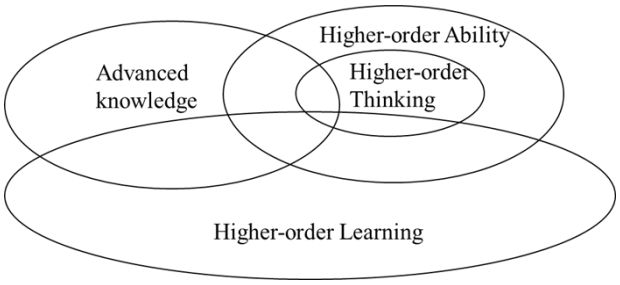

Figure 2. The relationship between concepts related to higher-order thinking

2.4. Learning/Teaching Model from the Perspective of Higher-order Thinking

Studies have found that the use of inquiry, discovery, exploration of learning methods, is conducive to the development of students' higher-order thinking ability, especially discovery learning. The development of higher-order thinking ability needs the support of higher-order learning activities, while higher-order learning belongs to constructivist learning mode in terms of teaching mode. It is a student-centered learning environment, and operation in this environment requires relevant knowledge and skills, as shown in table 1:

Table 1. Learning mode from the perspective of higher-order thinking

Examples	Learning Environment	Skill Requirements
Anchored Instruction	Narrative, storytelling, and real life situations	The ability to define the problem, the ability to abstractly generalize from the case
Open Learning Environment	Diversified Situation	Ability to be self-directed and self-managed
Project-based Learning	Collaborative, task-based learning environment	Management of information, self and others
Problem-based Learning	Complex and meaningful problem environments	Ability to identify and select resources for problem solving

3. Cultivation Strategies of Senior High School Students' Mathematics Classroom Teaching from the Perspective of Higher-order Thinking

As mentioned above, the cultivation strategies of higher-order thinking proposed in this study all occur after the improvement of students' lower-order thinking in mathematics. Specifically, they are implemented in each class, which is to form a diversified core activity group of lower-order thinking and higher-order thinking activities from low to high.

The cultivation of the high school mathematics higher-order thinking needs to be reflected in all aspects of life and learning, should not be confined to the classroom teaching. But the classroom teaching is the most effective way to develop students of higher order thinking, and the knowledge construction is to realize the classroom teaching middle school students of higher-order thinking development effective method. Therefore, according to the knowledge system of high school mathematics, this study designs the cultivation strategy of higher-order thinking, develops the higher-order ability of high school students in mathematics, and realizes the higher-order learning of high school students in mathematics

3.1. Initial Lesson -- Arouse Interest and Inspire Thinking with Methods

The difficulty of mathematics knowledge in senior high school is increasing. Compared with junior high school, students' thinking methods need to leap to the rational level, and mathematical language also changes in the degree of abstraction. For some students, the math becomes dry and, in turn, will loss of interest in mathematics learning, more can't talk about the development of their math higher-order thinking.Therefore, in the mathematics class needs to stimulate their interest in

learning, wake up their thinking vitality, especially in the initial class penetration.

In the classroom, mathematics should be fully displayed the charm of the subject, in order to stimulate students' interest in learning. The beginning of the new chapter in the mathematics class can guide students to find and ask questions from the specific situations in life. The concept of quality-oriented education advocates introducing the history of mathematics and the culture of mathematics into the classroom, so that students can understand the close relationship between mathematics and human social life in each period of its development, the development process of mathematics and the formation of mathematical thinking methods.

At the beginning of the new chapter, the learning method should be constructed as a whole to develop students' core accomplishment of mathematics. The development of discipline core literacy needs to go through three stages of knowledge understanding, transfer and innovation. It is a process from low-order thinking to high-order thinking, which needs to be completed through the knowledge construction of oneself. Of course, knowledge construction is an effective way for students to develop higher-order thinking. Only by transforming teachers' instilling teaching into students' own "learning" and allowing students to construct knowledge consciously, can we develop the core accomplishment of mathematics, train students' high-level thinking of mathematics and complete high-level learning.

3.2. Concept Lesson -- Situational Construction, Leading Thinking

The study of high school mathematics concept class requires a comprehensive and accurate understanding of the concept, and can correctly express, judge and reason on the basis of completing the low-order learning. In order for students to better understand the essence of concepts, teaching should pay attention to the design of concept introduction, so that students can realize the necessity of learning concepts, and guide students to rise from perceptual knowledge to rational knowledge to generate concepts[5].

Constructivism holds that knowledge is acquired by learners by means of meaning construction with the use of necessary learning materials under certain situations[6]. Therefore, an effective problem situation can promote the ideological exchange and thinking collision between teachers and students, so that students can better understand the origin of mathematical concepts, promote the construction of mathematical knowledge, and develop students' higher-order abilities such as thinking ability, exploration ability and innovation ability.

3.3. Inquiry Lesson -- Independent Inquiry, Flexible Thinking

The core educational concept of research-based learning education mode is to "let students feel and understand the process of knowledge generation and development"[7]. At present, research-based learning has made some progress in promoting the implementation of the cultivation of higher-order thinking ability in classroom teaching. Therefore, how to cultivate the higher-order thinking ability of senior high school students in inquiry class needs to combine the achievements of China's basic education reform, apply the scientific research methods of mathematics and acquire and apply mathematical knowledge. In inquiry class, students need to independently explore learning content in mathematics learning activities, discover, propose, explore and solve mathematical problems by themselves, to improve higher-order knowledge and develop higher-order ability.

Mathematics inquiry class plays an important role in cultivating students' higher-order thinking and developing students' higher-order ability. In order to develop students' thinking ability, teachers need to help students "recreate". In mathematics teaching, teachers create suitable conditions and reasonable specific situations, take knowledge as the carrier, let students actively construct on the basis of their experience, and participate in the "re-creation" of mathematical knowledge and methods[8].

In mathematics inquiry class, the study method of inquiry, discovery and inquiry should be used to enhance the initiative of students' independent inquiry. Four learning modes from the perspective of higher-order thinking have been mentioned in the previous paper. Multiple learning modes can be flexibly applied in mathematical inquiry class to guide students to explore and discover

independently, and to improve students' higher-order thinking abilities such as application ability, analysis ability, evaluation ability and creativity ability.

3.4. Review Lesson -- Reflection Summary, System Design

Review class, especially in the third year of senior high school, is different from the teaching of new knowledge. It is based on students' basic grasp of high school mathematics knowledge system and certain experience in solving problems. The purpose of the teaching of review class is to deepen students' understanding of knowledge, improve students' knowledge structure, make students internalize knowledge into their own knowledge, rebuild their own knowledge system, further exert students' initiative, improve students' core literacy of mathematics, and enhance their higher-order thinking ability. However, some teachers do not think that the review class can improve the students' higher-order thinking ability, so they continue to use the traditional review method and walk the same way again. Students only deepen the simple reproduction of knowledge points and problem solving methods, without integrating their own thinking, and fail to achieve the improvement of higher-order thinking ability.

In the review class, the teacher should guide the students to take the initiative to reflect on the summary and complete the construction of knowledge points for many times. Among them, the way of introspection and summary can be used to sort out the knowledge structure system with the help of mind map, incorporate them into one's own cognitive structure, and constantly improve one's own knowledge system. In addition, with the help of various learning modes and various forms of learning activities in the review class, students can be guided to extract different thinking methods in the review questions, so that their thinking can be sublimated in the study and higher-order learning can be realized.

4. Conclusion

High school students are faced with the college entrance examination. In order to cope with the college entrance examination, students are faced with heavy learning tasks and tight learning time. Therefore, many teachers do not pay attention to the cultivation of students' higher-order thinking. The disadvantages of the college entrance examination are shown: the test is oriented thinking, can not test the change of thinking mode. Test is the knowledge, not the discipline quality[9]. Therefore, the combination of college entrance examination knowledge and high-level thinking training design strategy is particularly important. This paper is a training strategy for senior high school students' mathematics classroom teaching from the perspective of higher-order thinking. It aims to develop higher-order thinking ability on the premise of ensuring students' knowledge acquisition. It does not disassociate the college entrance examination and abandons the purpose of college entrance examination, but also achieves the improvement of students' higher-order ability.

The purpose of cultivating advanced thinking ability in mathematics is not to make every student become a mathematician, but to let students develop the habit of thinking with mathematics through teaching, so that students can learn to see the world with mathematical eyes, think about the world with mathematical thinking, and express the world with mathematical language[10].The cultivation of students' high-level thinking is a lifelong benefit.

References

[1] Lorin W.Anderson, Laren A Sosniak. Bloom’s Taxonomy[M]. University of Chicago Press, 1994.

[2] Lirong Zhang. How to Cultivate Students' Higher-Order Thinking [J]. Beijing Education (General Education Edition), 2017(6): 85.

[3] Zhixian Zhong. The Purpose of Instructional Design:Promoting the Development of Learners' Higher Order Ability [J]. Electronic Education Research,2004(11):13-19.

[4] Zhixian Zhong. Teaching Design Framework for Knowledge Age [D]. East China Normal

University, 2004.

[5] Xuemei Sun, Weizong Zhu, Bo Wu, Xia Kang. Mathematics Teaching Design [M]. Harbin Institute of Technology Press, 2014.

[6] Junjun Zhao. A Brief Analysis of the Significance of Constructivism Learning Theory to Middle School Geography Teaching [J]. Examination Weekly,2021(23):143-144.

[7] Xiaoyan Sun, Guodong Liang. Some Thoughts on Guiding High School Students to Carry out Research Learning in Political Courses[J]. Love Science every day (teaching research),2021(05):2.

[8] Hui Lu. Creating Conditions to Promote Students' "Re-creation" Learning [J]. New Curriculum Guide, 2018(08):45.

[9] Xianguang Jiang, Changlong Zheng. Characteristics, Challenges and Strategies of Classroom Teaching with Subject Literacy as the Core [J].Educational Theory and Practice, 2017, 37(17):10-12.

[10] The Ministry of Education of the People's Republic of China. General High School Mathematics Curriculum Standard (2017 edition)[S]. Beijing People's Education Press, 2018.