Practical research on cultivating scientific thinking among high school students through biology mind mapping

--Take the experimental design of "Comparing the Decomposition of Hydrogen Peroxide Under Different Conditions" as an example

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Abstract: Under the new curriculum reform, teachers are required to aim at cultivating students' core competencies and cultivate students' scientific thinking in biology experimental teaching. This article takes high school biology experiments as the starting point, and selects the "Comparative Decomposition of Hydrogen Peroxide Under Different Conditions" experiment as an example to conduct experimental case studies. By optimizing the experimental teaching method, it is not limited to the materials and experimental plans provided by textbooks or literature, and explores how to use mind mapping in experimental teaching to implement the cultivation of students' scientific thinking.

Keywords: scientific thinking; core literacy; mind map; experimental teaching

1 Introduction

Today, with the rapid economic development, society's demand for labor talents has changed. Thoughtful thinking talents have become a new demand for social development. The cultivation of students' scientific thinking is a need to comply with the development of today's society. Against this background, countries around the world have successively begun educational reforms. The core competencies of high school biology subjects proposed in the "General High School Biology Curriculum Standards (2017 Edition, Revised in 2020)" (hereinafter referred to as the "New Curriculum Standards") include "the life of concepts, scientific thinking, scientific inquiry, social responsibility" [1~2], the inclusion of scientific thinking in the core competencies of the biology discipline shows that the cultivation of scientific thinking is one of the core goals of high school biology courses. The "National Medium and Long-term Education Reform and Development Plan Outline" also emphasizes the need to pay attention to the integration of learning and thinking, and adopt heuristic, inquiry-based, discussion-based, and participatory teaching to cultivate students' scientific thinking. A review of the literature shows that introducing mind maps in classroom teaching is helpful to help students quickly construct knowledge networks and thinking systems, improve students' information encoding and information extraction abilities, and thereby improve students' scientific thinking abilities. Mind Map was developed by British psychologist Tony Buzan. It is an organizational thinking tool [3]. Overseas, mind mapping has long been used in teaching to cultivate students' scientific thinking. Genevieve Pinto Zipp and other scholars combined mind mapping with effective teaching and proposed "Mind Mapping Learning Technique (MMLT)"), and concluded through research that the application of mind maps is conducive to improving students' scientific thinking ability [4]. Although related research in our country started relatively late compared to foreign countries, there have been corresponding studies in recent years, such as Zhao Xinhua's "Classroom Teaching is an Important Link to Cultivate Innovation Awareness". Research shows that mind maps are used to summarize teaching content and are beneficial to cultivating students. students' innovative ability[5]. On the basis of previous research, this article will analyze how to implement the use of mind maps in middle school biology experimental teaching to cultivate students' scientific thinking, and explore innovative teaching methods based on the implementation and optimization of the traditional organization and implementation of middle school biology experimental teaching. It provides certain reference and inspiration to front-line teachers who will teach biology experiments in middle schools in the future.

2 Components of scientific thinking

2.1 Induction and summary

Induction and summary are one of the important components of scientific thinking. In daily teaching, teachers lead students to conduct in-depth induction and summary of biologically related phenomenon descriptions, tabular data, and graphic analysis, rather than just focusing on facts and phenomena. Or the surface of the corresponding sub-conclusion, in order to improve students' scientific thinking ability.

2.2 Deduction and reasoning

Deductive reasoning usually requires individuals to speculate on the inevitable results under the assumption that certain mechanisms (rules) are established [6]. Deductive reasoning is widely found in middle school biology textbooks. By leading students to use deduction and reasoning, teachers can prove whether biological hypotheses or laws are reasonable, and can also explain biological facts theoretically. In the process, students can fully develop their scientific thinking.

2.3 Models and Modeling

Models and modeling are one of the important forms of “scientific thinking” in the core competencies of biology. Models can intuitively reflect the structure of objective things, and modeling is an important process for internalizing and reconstructing knowledge and concepts [7]. By leading students to build models in biology classroom teaching, teachers can visualize abstract problems and help improve students' scientific thinking abilities.

2.4 Critical thinking

The new curriculum standards clearly state that the curriculum objectives include cultivating students' critical thinking ability. Critical thinking belongs to the category of scientific thinking [8] and is an important scientific thinking tool. Integrating critical thinking content into biology teaching, strengthening students' critical thinking training, and strengthening the understanding and practice of critical thinking content in biology will help cultivate students' scientific thinking awareness and habits, and improve the overall quality of future citizens. thinking ability.

2.5 Creative thinking

Creative thinking refers to the conscious activity in which people process information and knowledge into ideals and actions to achieve creative results [9]. Innovation is an inexhaustible

driving force for a country's development and is also one of the important manifestations of scientific thinking. In biological experiment teaching, teachers encourage students to explore and innovate boldly on the basis of teaching the scientific knowledge discovered by their predecessors.

3 "Comparing the Decomposition of Hydrogen Peroxide Under Different Conditions" Experimental Teaching

3.1 Analysis of teaching materials

"Comparing the decomposition of hydrogen peroxide under different conditions" is the experimental content of Chapter 6, Section 1 of the Biology Compulsory Course 1 of the People's Education Edition. This section involves knowledge about scientific experiment processes and methods, which is very important for the entire biology experiment teaching and is an excellent material for inquiry experiment learning. By making full use of inquiry experiments, the knowledge transfer process is optimized into a scientific inquiry process. After students complete the experiments in the textbook, students are encouraged to share the difficulties encountered during the experiment, and students are guided through the use of induction and summary, deduction and Scientific methods such as reasoning and critical thinking are used to innovate experiments and promote the improvement of students' scientific thinking level.

3.2 Academic situation analysis

The teaching objects of this experimental class are high school students. Before studying this experimental class, students have already studied hydrogen peroxide decomposition and other related contents in junior high school chemistry. They have a certain knowledge base for learning the content of this class, but they are not familiar with it. The understanding of variables-related concepts, the use of single control experimental methods, and the ability to innovate experiments are relatively lacking. Therefore, in this biology experiment class, teachers should not only teach students relevant theories, but also focus on improving students' experimental inquiry abilities, deduction and reasoning abilities and other scientific thinking.

3.3 Teaching objectives

Based on the content requirements, teaching material requirements and academic quality standards of the curriculum standards, and focusing on the requirements for cultivating students' core competencies, the following teaching objectives are formulated:

(1) Understand the catalytic effect of enzymes by comparing the hydrolysis of hydrogen peroxide under different conditions. (the concept of life)

(2) Be able to use induction and generalization methods to explain experimental phenomena, and creatively design new experiments for further research. (scientific thinking)

(3) Master the basic ideas and methods of scientific inquiry, and learn to analyze the independent variables and dependent variables in the inquiry experiment of enzyme action. (scientific inquiry)

(4) Understand the practical application of enzyme engineering in real life and have certain plans for future career development. (social responsibility)

3.4 Important and difficult points in teaching

Teaching focus: (1) Understand the catalytic effect of enzymes by comparing the hydrolysis of hydrogen peroxide under different conditions.

(2) Analyze the relationship between the independent variables, dependent variables and irrelevant variables in the experiment, and learn to analyze the experiment.

Teaching difficulties: (1) Students learn the general methods of experimental inquiry.

(2) Encourage students to design experiments innovatively and conduct research independently.

3.5 Teaching process

Preparation before class:Students were divided into groups of 4 to preview the experiment "Comparing the Decomposition of Hydrogen Peroxide Under Different Conditions". They collaborated to explore within the group, summarized and summarized the corresponding experimental content in the form of a mind map, and wrote down the expected experimental phenomena.

Design intention: Cultivate students' habit of using mind maps, cultivate students' scientific thinking such as summary and induction, deduction and reasoning, and divergent thinking by drawing mind maps and hypothesizing expected phenomena. Cultivate students' interpersonal relationships and good habits through group cooperative learning. social adaptability and avoid the disconnection between theoretical knowledge and real life.

Lesson 1

Activity 1

Students: Each group displays the mind map of each group, and conducts inter-group evaluation, mentions the advantages and disadvantages of other groups' mind maps, and shares the opinions of this group on the shortcomings.

Design intention: Strengthen students' communication. When evaluating other people's mind maps, they can see the advantages of others and raise questions about the problems of each group, which is conducive to helping the group cultivate students' critical thinking.

Activity 2

(1) After the activity is over, the students are then led to draw a mind map as shown in Figure 1 [10]. Each group of students completes the experiment independently, and summarizes the problems encountered during the experiment and the shortcomings of the experiment. Write it down and discuss within the group to find out what good solutions are available to these problems.

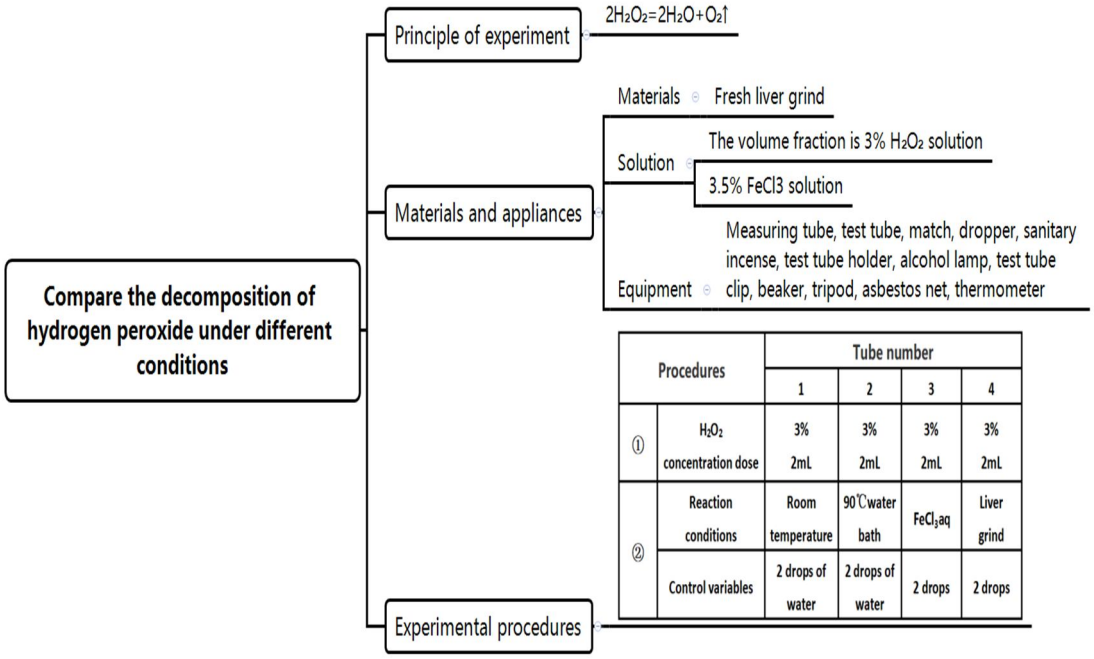

Figure 1 comparison of the decomposition of hydrogen peroxide under different conditions

(2) The teacher discusses and analyzes the independent variables, irrelevant variables, and dependent variables in turn. Regarding the independent variables and irrelevant variables, the teacher asked: What is the independent variable in this experiment? How to control the independent variable? How to achieve the single variable principle?

Design intention: In the process of leading students to draw mind maps, students can strengthen the induction and summary of the experimental knowledge, and at the same time, they can also exercise students' divergent thinking. Based on this, students become more familiar with the steps of experimental operations during independent experiments, which makes it easier to discover new problems during the experiment and innovate on the original experiments. Regarding the understanding of the variables that are the focus of this section, using the form of discussion to describe the variables can help students gain a deeper understanding of the experimental variables. At the same time, teachers can know the students' mastery level from the discussion.

Activity 3

Teacher: Students, what problems did you encounter during the experiment? Did you find a solution? Based on this experiment, what innovative ideas do you have? Everyone sends a representative to share in a small group? Students, let's work as a group to think about how to solve the above problems. Students can discuss or check the information online. If new experimental instruments are involved, submit the list of required instruments in groups before next week's experiment. To the teacher, we will continue in the next class.

Teacher: Summarize the unsolved problems that students encountered during the experiment:

Problem 1: Hygienic incense is not flammable, and the experimental phenomena are not intuitive and obvious enough.

Problem 2: Failure to quantitatively detect the oxygen production rate under different conditions.

Problem 3: Liver grinding liquid is difficult to grind and preserve, and it is also difficult to clean.

Question 4: Does catalase only exist in animals? Does it exist in plants? Bring the organisms you want to test to see if they contain catalase?

Design intention: Encourage students to be good at discovering problems and using them to solve problems, to raise their own questions about the textbook experimental plans, to explore independently and find new solutions to new problems. This process is conducive to promoting the cultivation of students' deduction and reasoning, critical thinking, innovative thinking and other scientific thinking.

Lesson 2

Activity 1

Teacher: Distribute the experimental equipment available to each group, organize students to share their group's solutions, and summarize students' solutions.

Students: Share the solution of this group, evaluate it between groups, introduce that this group wants to identify whether a certain organism contains catalase, and conduct the experiment (each group can conduct experiments with each other), and then evaluate which group's solution The plan is better.

Solution:

Question 1: (1) Balloon method: Put the balloon on the test tube and observe the change in size of the balloon.

(2) L-shaped tube method: Drop colored droplets into the L-shaped tube and observe the movement of the colored droplets within the same period of time.

Question 2: (1) Syringe method, inhale different equal amounts of solutions into the syringe. To ensure the airtightness of the device, use an antibiotic vial for infusion to hold the hydrogen peroxide solution, and observe the movement of the syringe scale.

(2) Use an oxygen detector to directly detect the oxygen content.

Question 3: The classmate checked the information and found that potatoes can be used to replace animal liver.

Question 4: The classmate checked the information and found that catalase exists not only in animals, but also in plants. The students brought common vegetables at home to test whether there is catalase, such as tomatoes, cucumbers, carrots, sweet potatoes, radishes, cabbage and other vegetables.

Design intention: Encourage students to explore new solutions and put them into practice instead of staying at the theoretical stage, which helps students establish eternal curiosity and strong love for science. In this process, students explore how to solve problems through independent learning, which promotes the cultivation of students' scientific thinking.

Activity 2

Teacher: Students, what have you learned through these two experimental classes? Share your insights? Discuss real-life uses of enzymes.

Design Intention: Through students' sharing, we can evaluate whether this biology teaching method is effective in students' scientific thinking, understand what kind of experimental class teaching method students like, and which teaching method can students learn the most knowledge. He led students to discuss the practical application of enzymes in real life, and subtly explained some career planning knowledge to students, breaking the barrier of biological knowledge remaining at the theoretical level.

3.6 Teaching analysis and reflection

In this class, compared with traditional classes, students are guided to apply mind maps in experimental learning. By constructing mind maps independently, students develop scientific thinking abilities such as induction and summary; this class is a confirmatory experiment. For exploratory experiments, traditional classroom teachers use the verification experiment class method. Based on the hands-on exploration of the experimental plans provided in the textbooks, students discover new problems from multiple angles during the experiment and independently explore new issues by accessing information online. solutions, students are hands-on throughout the entire process, effectively cultivating students' scientific thinking. However, there are also problems that need to be solved urgently. Students are not accustomed to using mind maps and are relatively

insensitive to finding problems. In the case of tight high school biology classes, it is necessary to explore how to implement the cultivation of students' scientific thinking within a limited time.

4 Conclusion

Biology experimental teaching is an important carrier for cultivating students' scientific thinking, and mind mapping is an important thinking tool. Introducing mind maps in biology experimental classroom teaching is conducive to cultivating students' hypertext reading ability, helping students construct knowledge networks and thinking systems, and improving students' information extraction and information encoding abilities. Through the process of independently constructing mind maps, students summarize and summarize biological experiments, network knowledge, and try to use critical thinking to view teaching material experiment plans to promote the cultivation of students' scientific thinking.

In the biological experiment teaching based on mind maps, students can summarize and summarize the experiments and critically recognize them during the experiment, and then ask new questions and have the courage to explore new experimental plans. At the same time, teachers can expand their reasonable thinking and verify the results. Sexual experiments are transformed into exploratory experiments, which are not limited to the materials and experimental plans provided by textbooks or literature, giving students the space to play freely, and to obtain sublimation of knowledge and improvement of abilities through discussion and review of materials.

Biology experimental teaching plays a decisive role in cultivating students' various scientific thinking and improving their manual and mental abilities. Through heuristic, inquiry-based, discussion-based and participatory teaching, it effectively trains students' thinking and manual and mental abilities, and actively thinks. Active exploration, learning to think proactively using scientific thinking methods, and applying the knowledge learned from practice into practice can stimulate students' interest in learning the subject of biology and help cultivate students' scientific thinking.

The cultivation of scientific thinking is not achieved overnight and requires a long-term process. Scientific thinking should run through the entire teaching process of biology, not only in experimental classes, but also in the teaching process of ordinary classroom teachers. Biological experiment teaching is the top priority to effectively cultivate students' scientific thinking, and it has a positive role in promoting the cultivation of scientific thinking. Through students' hands-on operations, exploration, induction and summary, and reasoning and deduction of experimental phenomena and experimental problems, teachers guide students to innovatively design new experiments based on experimental problems, encourage students to actively learn, and effectively cultivate students' scientific thinking.

5 Conclusion and outlook

Among the core competencies of the biology discipline, scientific thinking is an important component. On the basis of scientific thinking, students can establish certain the concepts of life through scientific inquiry, and will also have certain social responsibilities in the process [11]. In biology experimental teaching, teachers guide students to construct mind maps independently, summarize and summarize experiments while building knowledge networks, try to question the experimental plans of teaching materials, propose innovative plans, and promote the cultivation of scientific thinking. At the same time, mind map technology is used to analyze students' logical thinking and divergent thinking, and improve the effectiveness of memory of written information facts [12]; the learning method using mind map technology can improve students' learning effects in complex analysis procedures [13], train students' scientific thinking ability. In addition, biological experiments can stimulate students' interest in learning biological subjects, and they can also help students form correct biological concepts. During the learning process of biological experiments, students can improve their experimental skills and gain a deeper understanding of biological knowledge. Improve scientific literacy [14]. Therefore, teachers should conscientiously implement the cultivation of students' scientific thinking in biological experiments.

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