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Design of High School Biology Learning Activities Based on Scientific Practice

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Abstract: *This article takes "enzyme innovation experiment" as an example. In the real problem situation, based on the core literacy of the subject, it guides students to use knowledge and technology through scientific practice to cultivate students' high-level thinking, knowledge transfer and problem solving abilities.*

Keywords: *innovation experiment, core literacy, experiment teaching*

1. Introduction

The new version of the curriculum standard advocates students' active learning and practice, integrating students' life experience, problem solving, engineering design, discussion and decision-making, and hands-on practice throughout the content of the curriculum, emphasizing that the process of student learning is a process of active participation, through context creation And task-driven methods, carefully design a series of learning and practical activities, deepen the understanding of biological concepts in the hands and brains of students, and improve the ability to apply knowledge, and then use scientific viewpoints, knowledge, ideas and methods to explore or solve Certain problems in real life. As a first-line biology teacher, how to carry out scientific practical activities in experiments? Now take the experiment class "Enzyme Experiment" as an example to talk about how to carry out scientific practice based on experimental inquiry activities.

2. Determine the Content of Scientific Practice Activities Based on the Analysis of Textbooks and Academic Conditions

Scientific practice focuses on students' life experience and existing ideas, and teachers should determine the teaching content on the basis of analyzing students' academic conditions. The "Enzyme Experiment" section is an experimental class after learning the concept of enzymes, the characteristics of enzymes and the factors that affect enzymatic reactions. Through the study of enzyme theory classes, students understand that enzymes are a type of organic matter with biocatalysis. The characteristics of enzymes are specific, high-efficiency, and catalysis requires mild conditions. Temperature and pH affect the enzymatic reaction, which lays a good theoretical foundation for the exploratory experiments in this section.

The content of this section includes "Exploring the specificity and efficiency of enzyme catalysis" and "Experimental design of factors affecting enzyme activity". Based on the students' research ability and the existing experimental conditions in the laboratory, they have completed a lesson at the same time. The amount of class hours, the exploration of the efficiency and specificity of the enzyme, the exploration of the influence of temperature and pH on the enzyme activity are the focus of the exploration activities, and the exploration of the optimal pH of the enzyme is the difficulty of the exploration activities. Through a series of experimental exploration activities, the concept of "enzyme action characteristics and factors affecting enzyme action" is constructed, which also lays the foundation for the study of the next section "Exploring the Optimum Temperature of Enzymes".

3. Formulate Learning Goals Based on the Core Literacy Level of the Subject

According to the requirements of the curriculum standards, high school biology courses "can

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discover biological problems in the real world, carry out observation, questioning, experiment design, program implementation, and the ability to communicate and discuss results" and "can use existing Biological knowledge, evidence, and logic think about or demonstrate biological issues, and in the process of inquiry, master the ideas and methods of scientific inquiry, and improve the ability of scientific practice". Therefore, the learning objectives of this lesson are designed as follows:

(1) Understand the status and role of enzymes in the transformation of substances and energy in cells by understanding the properties of enzymes and the factors that affect their actions.

(2) Through carrying out experiments to explore the efficiency and specificity of enzyme catalysis and the factors affecting enzyme activity, try to design experimental schemes in accordance with the requirements of scientific practice, master the control principle and single variable principle in the experimental process and try to apply them.

(3) Able to implement inquiry activities according to the activity plan, record experimental results truthfully, use mathematical models such as tables and curves to record and analyze experimental results, and agree that scientific practice requires a scientific attitude of empirical evidence.

(4) Be able to apply the learned knowledge of enzymes to practice, face biological problems in real life, and use the knowledge and skills learned to participate in problem thinking and decision-making.

4. Scientific Practice Activities Run Through the Teaching Process

Traditional experiment teachers help students prepare experimental materials and equipment before experiments, and design experimental procedures. Students follow the experimental procedures to verify the known experimental results, turning the exploratory experiment into a verification experiment, and a "dumb experiment". The guiding ideology of the design of this lesson is to allow students to personally ask questions, select experimental materials according to the questions, design and use experimental equipment, make and implement experimental plans after discussion and decision-making, use rational thinking to form scientific explanations, use evidence to debate, and obtain , Evaluate and exchange information, and link experimental results with life experience, apply them in production practice, and internalize them into the knowledge structure of students. The teaching process includes three parts: the concept of enzymes, the characteristics of enzymes, and the factors affecting enzymatic reactions, including four exploratory experiments: exploratory experiment one (whether the enzyme is efficient) and exploratory experiment two (whether the enzyme has specificity), Explore experiment three (whether temperature and pH affect enzyme activity), and explore experiment four (what is the optimal pH of H2O2 enzyme).

4.1. Introducing Scientific Practice Based on Real Situations

Introduced by the video of white cat plus enzyme laundry detergent, asks the question: Enzymes are everywhere in our lives. Clothes pollution is treated with enzymes, and the stomach is not digested well. What enzymes are used? Introducing multi-enzyme tablets, this lesson uses the instructions of multi-enzyme tablets as the main thread throughout, leading to two themes of enzyme properties and factors affecting enzyme activity.

When students read the instructions for multi-enzyme tablets, they ask questions: Where is the enzyme produced? What is the main function of enzymes? What is the chemical nature of enzymes? Does the enzyme play a role in the cell after synthesis or outside the cell? Lead the students to review the concept of enzymes through questions: Enzymes are usually biologically catalyzed organic substances produced by living cells, most of which are proteins, and a small part are RNA. On the question of the chemical nature of enzymes, you can contact the experiments that students have learned to identify reducing sugars, proteins, and fats, and take H2O2 enzymes as an example to explore the nature of enzymes. Ask the question: Adding biuret reagent to H2O2 enzyme, the solution appears purple reaction, can it prove that the chemical nature of H2O2 enzyme is protein? If not, how can I prove it? The purple reaction of the solution does not mean that the chemical nature of the H2O2 enzyme is protein. It is necessary to design a set of egg white dilutions as a control group to draw conclusions. Guide students to design experimental control groups through questions, cultivate students' critical thinking, and understand that designing controlled experiments is one of the principles of biological experiment design.

Design intent: Scientific practice activities attach importance to being carried out in real situations,

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helping students to establish a connection between daily life experience, original daily concepts in their minds and scientific concepts, so that students realize that the original ideas in their minds cannot explain this The natural phenomena in the situation produce cognitive conflicts, and then guide students to explore scientific concepts, and then meaningful learning is possible.

4.2. Whether the Enzyme has a High-Efficiency Exploration Experiment

4.2.1. Ask Questions and Make Assumptions

Show the instructions for multi-enzyme tablets: [Ingredients] 300 mg of pancreatin and 13 mg of pepsin. Ask the question: Is there any effect if the enzyme content is so small? Why? In response to these questions, the first exploratory experiment is carried out: whether the enzyme is highly efficient.

4.2.2. Organize Students

Develop a plan to organize students to use the given experimental materials (hydrogen peroxide solution, liver slurry, potato slurry, FeCl3, test tube, dropper, sanitary incense, matches, etc.), discuss in groups, and go independently Develop experimental plans and design experimental record forms independently. Ask the question: What does test tube 1 and test tube 2 compare? What does the comparison of test tube 3 and test tube 4 show? Clarify the principle of biological experiment design: the principle of control. Ask the question: What are the independent and dependent variables of this experiment? Which factors are irrelevant variables? How to control irrelevant variables? Instruct students to clearly design the experiment to clarify the independent variables and dependent variables of the experiment, and the irrelevant variables should be consistent and appropriate. After the students design the form, they use Seewo's teaching assistant to project the results to display and communicate.

Design intent: Let students construct their own research methods for exploring experiments through the efficient exploration experiment of enzymes: ask questions (whether enzymes are efficient), make assumptions (enzymes are efficient), design and implement experiments (please use the given experimental materials) Explore the high efficiency of enzymes), observe experiments, and draw conclusions for subsequent migration applications.

4.2.3. Implementation Plan

Each team selects materials to start the experiment according to the experimental party, observes the experimental results and records the experiment. Some groups took the bubble generation as the dependent variable, and observed that the experimental phenomenon using liver slurry as the material was obvious, and the amount of bubbles generated by adding enzymes was significantly greater than that of inorganic catalysts. The experimental phenomenon using potato milling liquid as the experimental material is not obvious, and the response is not rapid enough. Some groups chose to reignite the hygienic incense as experimental materials, but the hygienic incense did not reignite. The students speculated that the generated oxygen gas was too little to allow the hygienic incense to reignite. Some students tried to plug the test tube mouth with their hands. Increase the oxygen content, repeat the experiment, the result of the experiment is still not ideal.

Design intent: Let students choose experimental materials independently, design experimental forms independently, experience the process of experimental inquiry, feel the essence of biology is based on empirical science, analyze experimental results in the inquiry, experience the uncertainty of experimental results, and experience scientists exploring experiments The hardship of the process.

4.2.4. Draw Conclusions

The comparison of test tube No. 1 and test tube No. 2 proves that the enzyme is catalytic; the comparison of test tube No. 2 and No. 3 test tube proves that the enzyme is highly efficient. This experiment also proves that using liver grinding fluid as the experimental material, observing the amount of air bubbles, the experiment is easier to succeed.

4.3. Whether the Enzyme has a Specificity Exploration Experiment

If the experiment of the H2O2 enzyme catalyzed decomposition of H2O2 in test tube No. 3 is changed as follows: Replace the enzyme—fresh liver slurry is replaced with amylase, what will be the result of the experiment? The students added amylase to the No. 4 test tube and observed the experimental phenomenon: similar to the formation of bubbles in the No. 1 tube, they concluded that the enzyme is specific, and an enzyme can only catalyze a chemical reaction of one or one type of

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substance. The teacher then asked the question: Are there any other options for exploring the specificity of enzymes? Talk about your ideas. After discussion, the students answered that the enzymes are the same but the substrates are different.

Design intent: Limited by the class time, if the experiment is carried out according to the specificity of the enzyme in the book, the time is not enough. By replacing the enzyme, it was ingeniously proved that the enzyme has specificity.

4.4. Exploratory Experiments on Whether Temperature and pH Affect Enzyme Activity

4.4.1. Ask Questions and Make Assumptions

Show the instruction manual of the multi-enzyme tablet, remind students to pay attention to the [Caution] in the instruction: This product should not be taken with overheated water, and should not be taken with acidic or alkaline drugs. Ask the question: Why should we pay attention to the conditions of taking multi-enzyme tablets? Such problems come from life, can stimulate students' thinking and arouse students' desire to explore. Students make a hypothesis: high temperature, strong acid and strong alkali will affect the activity of enzymes.

4.4.2. Develop a Plan and Implement the Plan

Let students add 5 drops of H2O2 solution to potato chips and bananas that have been processed (high temperature, normal temperature, low temperature, strong acid, neutral, strong alkali), respectively, and observe the phenomenon, 1 to 4 groups Use potato chips, 5 to 8 groups use banana chips to do the experiment, observe and compare the results of the experiment. Ask questions when doing the experiment:

[Thinking 1] In the experiment, can I drop the H2O2 solution on the material first, and then perform the corresponding treatment?

[Thinking 2] Observe the experimental phenomena again and think: Can the effects of low temperature, high temperature, overacid and overalkali on enzyme activity be restored? Talk about your reasons.

4.4.3. Observing Phenomena and Drawing Conclusions

The experimental phenomena observed by students are: there are many bubbles in the normal temperature and neutral groups, less bubbles in the low temperature, acid, and alkali groups, and no bubbles in the high temperature group, and the experimental effect of bananas is better than that of potatoes. It is concluded that high temperature, excessive acid, and excessive alkali have destroyed the spatial structure of the enzyme and cannot be restored; low temperature only reduces the activity of the enzyme, which can still be restored when the temperature is increased.

Design intent: Through a simple experiment to explore the factors affecting enzyme activity, the experimental results are obvious. Through the use of different experimental materials to carry out experiments, cultivate students' experimental analysis ability. The experiment also provides different experimental materials such as sweet potatoes and yams for students to repeat the experiment, so that students feel that there is biological knowledge everywhere in life, and biology and life are closely connected, which triggers students to think about a question: There is catalase in potatoes and bananas. It is also found in sweet potatoes, yams, and animal livers. Does catalase exist in different organisms?

4.5. Explore the Optimal pH of Catalase

Asking questions and making assumptions Asking questions: How to further explore the optimal pH of catalase? Some students make the hypothesis: each enzyme has its optimal pH range, and high or low pH will cause the enzyme activity to decrease; some students make the hypothesis: the optimal pH of the H2O2 enzyme is around 7.

Make a plan for students to use the experimental materials provided by the teacher: hydrogen peroxide solution with pH 3, 5, 7, 9, 11, potato chips (groups 1, 2, 3, 4), soaked in yeast solution Filter paper (groups 5, 6, 7, 8), stopwatch, measuring cylinder, etc., to design the experimental process. Each group internally designs and communicates and demonstrates the experimental plan, discusses the experimental design plan, summarized as follows: ①Take six graduated cylinders, number them, and add 80ml of hydrogen peroxide solution with PH 3, 5, 7, 9, 11, 13 respectively; ②Put potato chips of the same size and thickness or filter paper immersed in the yeast solution into the measuring cylinder in

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turn, and record the time from falling to floating in time; ③Draw the pH of catalase versus the experimental results The curve of time.

Implementation plan According to the experimental design plan, students use a stopwatch to record the time from falling to floating of potato chips or filter paper, and design a table to record the experimental results.

According to the results of the experimental records, the data is converted into a graph. The experiment results show that the optimal pH of catalase in potatoes is not 7, but around 11. Students analyzed the results of the experiment. Some students speculated that the potato slices were not soaked in hydrogen peroxide solution before the experiment, but just a superficial one. The layer is immersed in hydrogen peroxide solution, so the result is not accurate. After class, you can continue to explore whether the optimal pH of catalase is different between the potato chips soaked before the experiment and after the experiment; some students speculated that the rise time and potato chips The size of the potato is related to the thickness. In the experiment, the thickness of the potato is different, which affects the result of the experiment and the speed of ascent. In comparison, using potato chips to float is more accurate than filter paper soaked in yeast solution. The filter paper soaked in yeast solution is affected by water resistance and is not easy to float up.

Draw conclusions Every enzyme has its optimum pH range. High or low pH will cause the enzyme activity to decrease. Many organisms in life contain H_2O_2 enzyme, and the optimum pH of H_2O_2 enzyme is different in different organisms.

Design intent: Through students' self-selection of experimental materials, active participation in the learning process, the acquisition of biological knowledge in the process of asking questions, obtaining information, searching for evidence, testing hypotheses, etc., to improve students' scientific practice ability and comprehend that biologists are in scientific inquiry The ideas and methods of solving problems in the middle school, experience the hardships of scientists' experiments and the unremitting spirit of exploration, and stimulate the motivation of students to do scientific research.

5. Conclusions

Further exploration Ask the question: How to further determine the optimal pH of the H_2O_2 enzyme? Are there H_2O_2 enzymes in different organisms? Is the optimal pH of H_2O_2 enzymes in different organisms the same?

Scientific practice emphasizes in the teaching of biology courses, guiding students to ask questions and clarify difficult problems; make and use models, formulate and implement research plans, analyze and explain data, use mathematical and computing thinking, form scientific interpretation, design engineering solutions; use evidence to debate, obtain, evaluate and exchange information. In the experimental section of Enzyme, the students personally participate in the experiment and make innovative design of the enzyme experiment. The students learn thinking in the process of analyzing problems and solving problems, cultivate the students 'ability of scientific exploration and practice, and develop the students' core literacy.

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