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The Teaching Design of Developing the Core Literacy of Chemistry Based on the History of Chemistry -Taking 'the Nature of Chlorine 'as an Example

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Abstract **Original Research Article**

In recent years, with the implementation of new curriculum standards, senior high school chemistry education has increasingly emphasized the cultivation of students' core qualities. As an important resource of chemistry teaching, the history of chemistry provides us with a new teaching perspective. But the teaching of the history of chemistry is often neglected or used only as auxiliary material. This paper takes the teaching design of "The nature of chlorine Gas" as an example, and takes the "historical line" of chlorine gas discovery, the "activity line" of students' learning, the "knowledge line" of chlorine gas properties and the "quality line" of students' expected achievement as the teaching route of this class, and discusses how to integrate the history of chemistry into the chemistry curriculum of high school in order to improve students' core quality of chemistry, cultivate students' patriotic feelings and rigorous and realistic scientific attitude.

Keywords: History of Chemistry, Core Literacy of Chemistry, Instructional Design

The "General High School Chemistry Curriculum Standards (2017 Edition, 2020 Revision)" (hereinafter referred to as the "New Curriculum Standards ") clearly points out the key to comprehensively cultivating students ' core literacy in chemistry, emphasizing the "literacy-based " educational concept[0]. The cultivation of core literacy should be based on core knowledge and carrier[2]. Classroom teaching is the key place to cultivate students ' core literacy. As an important part of chemistry education, the history of chemistry can help students better understand the evolution and development of chemical theory, stimulate their interest and curiosity in chemistry, and integrate it into chemistry teaching, which is an important measure in line with the development trend of education. However, in traditional chemistry teaching, the teaching of chemical history is often neglected or only used as an auxiliary material. The purpose of this paper is to study the teaching design of implementing the core literacy of chemistry discipline based on the background of chemistry history, so as to meet the current teaching challenges. The teaching activities are designed for the class of " the nature of chlorine gas " in the compulsory first volume of the new people 's education edition, and the cultivation of students ' core literacy of chemistry discipline based on the teaching of chemistry history is analyzed, which is intended to provide useful reference and enlightenment for chemistry teaching.

1.CONNOTATION AND VALUE OF CHEMICAL HISTORY

The history of chemistry is a systematic exposition of the process and achievements of human beings ' continuous exploration of natural chemical knowledge through social practice in the long history[3]. It includes a series of discoveries, theoretical innovations, advances in experimental technology, and contributions from scientists. The history of chemistry is not only the timeline of events, but also involves the development of scientific methods, the evolution of scientific ideas and the influence of science on society and technology. The value of chemical history is that it can provide rich teaching resources for modern chemistry education, help students better understand the formation and process of chemical concepts, and recognize the development and relativity of scientific knowledge. The " new curriculum standard " points out that it is necessary to " combine the history of human exploration of substances and their changes with the trend of the development of chemical science in classroom teaching, and guide students

to further learn the basic principles and methods of chemistry " [4]. Therefore, the integration of chemical history education into classroom teaching is in line with the trend of educational development. Incorporating the history of chemistry into teaching, students can not only experience the process of scientific inquiry, cultivate scientific thinking and critical thinking ability, but also stimulate students ' enthusiasm for chemistry learning, enhance learning motivation, and then implement the core literacy of chemistry.

2.THE SIGNIFICANCE OF IMPLEMENTING THE CORE LITERACY OF CHEMISTRY DISCIPLINE

Chemistry is an indispensable key component in the field of natural science. Cultivating students ' core literacy of chemistry is a key aspect of its development. The core literacy of chemistry refers to the correct values, necessary characters and key abilities that students gradually form in the process of learning through chemistry courses to adapt to personal lifelong development and social needs, reflecting the ' basic requirements of chemistry education under the socialist core values ' [5]. The " new curriculum standard " condenses the core literacy of chemistry from five dimensions, including " macro identification and micro analysis, " " change concept and balance thought, " " evidence reasoning and model cognition, " " scientific inquiry and innovation consciousness, " " scientific attitude and social responsibility. " The core task of chemistry teaching should focus on cultivating students ' core literacy of chemistry, and integrate this goal into all aspects of chemistry teaching. Teachers can make full use of the resources of chemistry history as a way to comprehensively promote the development of students ' core literacy of chemistry [6] .

In classroom teaching, the implementation of the core literacy of chemistry helps to improve students ' scientific literacy, enable students to use chemical knowledge to solve practical problems in life, and cultivate innovative thinking and scientific inquiry ability. The essence of promoting the improvement of core literacy is to promote the dual emphasis of chemistry curriculum and students ' humanistic heritage and core literacy training[7]. At the same time, the core literacy of chemistry emphasizes the cultivation of students ' autonomous learning and lifelong learning ability, which is of great significance for students to adapt to the rapidly developing society.

3.TEACHING DESIGN

The history of chemistry reflects the scientific thinking, scientific attitude and scientific spirit of the sages, which is very consistent with the core literacy of chemistry [8]. Instructional design is a process of using systematic scientific methods based on teaching theory, learning theory and communication theory. It involves in-depth analysis, careful planning and specific arrangement of teaching elements and links such as teaching objectives, content, media, strategies and evaluation methods[9]. This lesson combines the relevant records of chemical history, and uses chemists to explore the ' historical line ' of chlorine gas, the ' activity line ' of students ' learning, the ' knowledge line ' of chlorine gas properties, and the ' literacy line ' expected by students. The teaching design corresponds each history to the corresponding inquiry activities, chemical knowledge, and core literacy, and perfectly integrates chemical history and chemistry teaching.

3.1 Textbook Analysis

The ' nature of chlorine ' belongs to the first class of ' chlorine and its compounds ' in the second section of the second chapter ' important elements in seawater-sodium and chlorine ' in the compulsory chemistry of senior high school of new people 's education edition. This part of the content occupies a very important position in the textbook. Chlorine is a typical non-metallic element. The study of chlorine is not only the starting point of non-metallic element content, but also lays a foundation for learning other non-metallic elements and understanding the properties of halogens and the periodic law of elements. Therefore, it plays an important role in the curriculum, and it is the key content that high school students must learn. The content of the textbook takes chlorine gas as the main line. Through the introduction of the use of chlorine gas, the physical and chemical properties of chlorine gas are comprehensively described, including the reaction of chlorine gas with metal and non-metal elements and the reaction of water and alkali solution. This will help students master the correct learning methods, strengthen experimental skills, and stimulate students ' awareness of inquiry. In addition, the textbook also emphasizes the wide application of chlorine in human production and life, as well as its impact on the ecological environment. This helps to guide students to understand the logical relationship between structure and nature, nature and use, cultivate the ability to analyze problems dialectically, establish a correct scientific attitude, enhance social responsibility, and subtly improve students ' core literacy of chemistry.

3.2 Analysis of Learning Situation

The students in the first grade of senior high school have learned the basic knowledge of chemistry, such as the classification and transformation of substances, ion reaction, redox reaction in the first chapter and the related knowledge of sodium and its compounds in the first section of the second

chapter, which lays a foundation for learning the properties of chlorine gas. Students also learn about the basic types of chemical reactions, such as redox reactions, displacement reactions, etc. This knowledge helps to understand the reaction of chlorine with other substances. The students are quick in thinking, have a strong desire for knowledge, and have been exposed to inquiry experiments or confirmatory experiments in the past, which has laid a certain experimental foundation. They have the ability of preliminary observation, hands-on experiments and analysis and problem solving, but these skills are still immature and lack systematic and correct guidance of scientific inquiry methods. In addition, chlorine, as a gas with a pungent odor and a special color, has a certain attraction to students. It can induce students ' curiosity, mobilize students ' enthusiasm, and help to improve students ' interest in learning.

3.3 Teaching Objectives

The teaching goal is the cornerstone of all educational goals, which provides direction for each learning stage and serves as a benchmark for assessing learning effectiveness[9]. The following is the presupposition of the teaching objectives of the ' Nature of Chlorine ' class:

3.3.1 By analyzing the three dimensions of atomic structure, material category and element valence state, and combining the viewpoint of redox reaction, the chemical properties of chlorine are predicted and explained, and the macro-micro combination is realized, and then the ' cognitive model ' for the speculation and verification of material properties is constructed.

3.3.2 Combined with the real situation, through the experiment to explore and understand the physical properties of chlorine, to master its chemical properties, to deeply understand the key role of the experiment in understanding and studying the properties of substances, to cultivate the ability of experimental inquiry and summary, and to understand the consciousness of ' evidence reasoning '.

3.3.3 By learning the nature and use of chlorine-containing substances, we can feel the close relationship between chemistry and life, realize the important role of chemistry in improving the quality of life and environmental protection, and cultivate students ' core literacy of ' scientific attitude and social responsibility '.

3.3.4 Taking the study of the chemical history of chlorine-containing substances as a guide, we should learn the inquiry spirit of scientists and cultivate students ' awareness of scientific inquiry and innovation.

3.4 Teaching Process

3.4.1 Contact the real situation, import new lessons.

[Situational introduction] During the epidemic, we can always smell a special smell when we go shopping in supermarkets, or enter public places such as schools and hospitals. That's when staff are using disinfectants to disinfect the premises to make sure we can operate in a relatively safe environment. What disinfection supplies do the students know?

[Physical display] Bleaching powder, chlorine dioxide effervescent tablets and 84 disinfectant.

[Teacher guidance] Why can these substances be disinfected? What are their main components and what are their properties? In this lesson, let us learn the content of the first class of the second section of the second chapter " chlorine and its compounds ": " the nature of chlorine. "

Design intent: Through the introduction of new courses in real situations, students can feel the widespread existence of chlorine and its compounds and their important applications in production and life, stimulate students ' interest in learning, and realize that chemistry is a subject closely related to life.

3.4.2 Physical properties of chlorine and atomic structure of chlorine.

[Multimedia display] In 1774, Swedish chemist Scheler studied pyrolusite (the main component is MnO_2) and found that when pyrolusite was mixed with concentrated hydrochloric acid and heated, a new yellow-green gas with irritation was generated. This gas is the chlorine we are going to learn today.

[Teacher 's question] Through the story of Scheler 's discovery of chlorine, do you know how to prepare chlorine? What physical properties of chlorine can you sum up?

[Teacher activities] The teacher shows the chlorine gas collected in advance and shows the relevant data cards (melting point, boiling point, density).

[Students ' summary]

(1) Color: yellow-green;
(2) State : gas ;
(3) Odor : irritating odor ;
(4) The melting and boiling point is low, so it is gas at room temperature;
(5) Density is greater than air density.

[Teacher 's question] If we want to study the physical properties of matter, which angle can we cut into?

[Student activity] Group to think about the discussion, contact the known, think of ' solubility '.

[Teacher demonstration] chlorine solubility inquiry experiment: the water in the syringe into the well collected in advance of the plastic bottle filled with chlorine, shake the bottle, please students to observe the experimental phenomenon.

[The student replied] The bottle filled with chlorine gas became shrunk.

[Teacher 's question] Why does this phenomenon occur?

[Student replied] The chlorine dissolved in water so that the air pressure decreased, so the bottle shrunk.

Design intent: To construct a general model for studying the

physical properties of substances (from the aspects of color, state, odor, toxicity, solubility, etc.), and to experience scientific inquiry methods. The students observed that the plastic bottle shriveled, analyzed the microscopic reasons from the macroscopic phenomenon, and intuitively felt the solubility of chlorine in the aqueous solution, laying a foreshadowing for the exploration of the reaction of chlorine water.

[Consideration 1] Chlorine is a widely used substance, and its use under the requirements of safety norms is of great significance to the development of human society. We often liquefy the chlorine gas and then transport it, but if there is a chlorine gas leak in transit, how should we deal with it?

Design intent: Through thinking 1, feel the role of chemistry in solving problems in real situations, and reflect the educational value of chemistry.

[Teacher activity] Shows microscopic models of chlorine atoms.

[Teacher 's question] Ask the students to try to draw the atomic structure of chlorine and speculate its nature.

[The student replied] The outermost electron arrangement of the chlorine atom contains 7 electrons, which makes it easy to achieve a stable configuration of 8 electrons by accepting one electron in the chemical reaction. This process gives chlorine a significant oxidation ability, so chlorine is a kind of active non-metallic element with strong oxidation.

Design intent: From the perspective of atomic structure, combined with the viewpoint of redox reaction, macro and micro combination, predict and explain the chemical properties of substances, understand the logical relationship between structure and nature, and implement students ' macro identification and micro analysis of core literacy.

3.4.3 Reaction of chlorine with water.

[Multimedia display] After Scheler discovered chlorine gas, in 1785, the French chemist Bertolé introduced chlorine gas into a cold glass bottle to condense the acid-containing vapor in the chlorine gas, and then passed the chlorine gas through three water-filled reagent bottles in order to make the chlorine gas fully dissolved.

[Consideration 1] According to the physical properties of chlorine, we have known that 1 volume of water can dissolve about 2 volumes of chlorine. So is chlorine simply dissolved in water or reacts? Ask the students to discuss the group to put forward your conjecture, and from the perspective of element conservation analysis of chlorine water which particles may exist?

[Students ' inquiry]

Hypothesis	Particulate composition
Hypothesis 1: Simple dissolution	
Hypothesis 2: Both dissolution and reaction	
Hypothesis 3: Complete response	

Design intent: To understand the significance of scientific research methods and rigorous and realistic attitude to chemical research and to arouse students ' thinking. This paper analyzes the particulate components in chlorine water from a micro perspective, and develops students ' evidence reasoning and model cognition, macro identification and micro analysis of the core literacy of chemistry.

[Teacher activities] Based on the assumptions made by students, the instruments and reagents are used to allow students to conduct group discussions and design experiments for verification. (required instruments: test tube, glass, glue dropper, glass rod, colored paper, pH test paper, etc.; required reagents: chlorine water, litmus test solution, silver nitrate solution, magnesium powder, etc.)

[Teacher guidance] In the process of group discussion, teachers guide students to think and analyze from macro phenomena and micro particles.

[Student answer] The experimental design is as follows:

Experimental content and operation	Experimental phenomenon	Experimental conclusion
1. Observe the color of chlorine water	Chlorinated water is yellowish-green	The solution contains Cl_2

2. Take a small amount of chlorine water in the test tube and add appropriate amount of $AgNO_3$ solution into the test tube	A white precipitate is produced	The solution contains Cl^-
3. Take a small amount of litmus test solution in a test tube and add appropriate amount of chlorine water into the test tube	The solution turns red and then fades	The solution must contain H^+

[Student activities] Students complete the relevant experimental verification, pay attention to observe the experimental phenomena and make corresponding records.
[Teacher guidance] Continuous guidance in the process of students ' experiments.
[Teacher summary] From the experimental conclusions drawn by the students, chlorine can be dissolved in water and can react with water.
[Thinking 2] Students are invited to write the chemical reaction equation of chlorine gas and water from the perspective of element conservation and redox reaction principle.
[Teacher 's question] When chlorine water was added to the test tube in Experiment 3, the solution turned red first and then faded. So what is this bleached substance?
Chlorine gas or generated hypochlorous acid (HClO).
[Teacher activities] Guide students to think further and design experimental programs.
[Student experiment] Take a dry, moist colored paper strip each, were placed in two gas cylinders containing dry chlorine, covered with glass.
[Teacher activities] Guide students to draw conclusions in groups.
[Student answer] Wet colored paper color fades, while the dry colored paper remains the same, the only variable is water. At room temperature, chlorine gas dissolved in water reacts with water to form hypochlorous acid (HClO), which has strong oxidizing property.
Design intent: Let students deeply understand the essence of chemistry as an experimental science through chemical experiments, that is, to experience the whole process of discovering problems, constructing hypotheses, designing experimental schemes, performing experiments, observing phenomena, collecting data, processing information and drawing scientific conclusions in the experimental process, so as to establish scientific inquiry methods and general scientific research models.
[Multimedia display] French chemist Beretto also found that chlorine water can be dewed in the sun to produce hydrochloric acid and oxygen.
[Teacher 's question] How is oxygen produced here?
[Student activities] Read the textbook Science-Technology-Society column to verify the digital experiment of hypochlorous acid light decomposition products. According to the trend of the curve after illumination, the chemical equation of HClO decomposition was inferred and the experimental record was completed.

Phenomenon	Conclusion
After exposure to light, the pH value of chlorine water decreases, the concentration of chloride ions increases, and the volume fraction of oxygen increases.	Hypochlorous acid breaks down under light and reacts to chemical equations: $2HClO \overset{hv}{=\!=} 2HCl + O_2 \uparrow$ Hypochlorous acid is weakly acidic, unstable and easy to decompose.

[Teacher activities] Summarize the properties of hypochlorous acid.
[Thinking 3] What are the molecules and ions in the new chlorine water? What about the long-standing chlorine water?
Design intent: Through digital experiments, we can understand the significance of scientific and technological development to scientific research. From macro to micro, we can analyze the molecules and ions in chlorine water, and implement macro identification and micro analysis of the core literacy of chemistry.
3.4.4 Reaction of chlorine with alkali.
[Multimedia display] By introducing chlorine into plant ash, Bertore successfully made liquid bleach. Subsequently, in 1789, based on Betore 's research, the British chemist Tenet innovatively dissolved chlorine in lime milk (Ca (OH) $_2$) to produce bleaching powder. In view of the low cost and high

stability of bleaching powder, this preparation method is still widely used in industrial production. Next, we will play a video on the industrial bleach preparation process.

[Teacher's narration] The industrial production principle of bleaching powder: $2Ca(OH)_2 + 2Cl_2 = Ca(ClO)_2 + CaCl_2 + 2H_2O$. In fact, the production principle of bleaching liquid is similar to that of bleaching powder, and the essence is that chlorine reacts with alkali. The difference is that the bleaching solution is prepared by the reaction of chlorine and sodium hydroxide.

[Teachers ' guidance] Ask students to write out the production principle of bleaching liquid according to the production principle of bleaching powder.

Design intent: Through the historical materials of chemist Tenet 's preparation of bleach powder, students can learn the reaction of chlorine and alkali, understand the preparation principle of common material bleach solution and bleach powder in life, and let students realize the close relationship between chemistry and life production.

3.4.5 Reaction of chlorine with metal and nonmetal elements.

[Multimedia display] In 1810, David confirmed that chlorine was a simple substance and chlorine was a new element by electrolysis.

[Teacher activities] Guide students to write chemical equations for the reaction of chlorine with sodium, iron and copper by analogy with oxygen.

	O_2	Cl_2
Reaction with sodium		
React with iron		
Reaction with copper		

Design intent: By analogy with oxygen, students can realize that knowledge transfer is an important learning method.

[Thinking 1] From the first discovery of chlorine by Scheler in 1774 to the final confirmation of chlorine as a new element, this process has spanned more than 30 years, during which many scientists have made unremitting exploration and research. What enlightenment can students get from this historical event?

Design intent: To enable students to experience the hardships of scientific research, so as to cultivate a rigorous and realistic, meticulous scientific attitude and the ability to obtain and use information.

[Multimedia display] In 1809, chemists Gai-Lussac and Tynar mixed the same amount of hydrogen and chlorine and placed it for a few days. Through light or slight heat, hydrochloric acid gas could be produced.

[Teacher 's guide] Ask students to write the chemical equation of the reaction of hydrogen and chlorine.

Design intent: Through the reaction of hydrogen and chlorine, we can feel the concept of material change, compare it with the " combustion " learned in junior high school, explore the essence of combustion, feel the innovation and improvement of knowledge, and experience the consciousness of scientific inquiry and innovation.

3.4.6 Wide application of chlorine properties.

[Multimedia display] Chlorine is used for disinfection of drinking water : In 1908, the United States began to use chlorine to disinfect drinking water, which greatly reduced many diseases caused by dirty water. At present, China has formulated the standard of residual chlorine content in drinking water, and has begun to use other tap water disinfectants, such as chlorine dioxide and ozone.

[Teacher 's question] Based on the above materials, what are the implications for students?

Design intent: Through the disadvantages of chlorine disinfection, students ' dialectical thinking on science and correct understanding of chemistry are triggered. Students can realize the impact of chlorine and its compounds on life, feel the close relationship between chemistry and life, realize the significance of chemistry to environmental protection, appreciate the significant contribution of chlorine and its compounds to social development, and implement the core literacy of ' scientific attitude and social responsibility '.

3.5 Teaching Evaluation and Reflection

3.5.1 In many teaching designs and cases of " the nature of chlorine gas, " " chlorine gas toxic bomb during World War II, " " chlorine gas leakage in chemical plants, " " tank truck accident with liquid chlorine " are introduced as situations, which are intended to stimulate students ' interest in learning. However, in the early stage of teaching, too much emphasis on the toxicity of chlorine gas and its negative impact on human beings and the environment has virtually branded the science of chemistry as 'toxic, harmful and dangerous ', which has led students to fear chemistry and even reject chemical experiments, thus concealing the great contribution of chemistry to human development. Therefore, we should reasonably design the teaching situation to highlight the value of chemistry.

3.5.2 ' Science gives people knowledge, and the history of science gives people wisdom '. The teaching design of this class is based on the historical facts of chemistry to design problems

to drive students to think, reflecting the educational value of chemistry. In the teaching, the historical facts of chemistry are organically linked with the study of the properties of chlorine gas, reviewing the scientists ' discovery of chlorine gas, exploring the properties of chlorine gas, the process of applying chlorine gas, and then using modern digital technology to study the decomposition products of hypochlorous acid. Feel the convenience brought by the development of science and technology, learn the methods of scientific research, and experience the hardships of scientific research and the rigorous and realistic scientific attitude.

3.5.3 Through these historical lines and corresponding teaching activities, students can better understand the historical development of chemistry, and link chemical knowledge with actual situations, and the teaching process is relatively complete. At the same time, each link emphasizes the implementation of the core literacy of the corresponding chemistry discipline. However, in the specific teaching implementation process, there are still some problems that need to be improved. For example, due to the particularity of chlorine gas, the opportunity for students to start hands in the experiment is limited. Therefore, the opportunity for students to operate the experiment should be increased to promote the better integration of knowledge and skills.

4.CONCLUSION

Integrating the history of chemistry into high school chemistry teaching can not only enable students to understand the chemical knowledge of the nature of chlorine more comprehensively, but also cultivate students ' comprehensive quality at a greater level and improve their historical consciousness, scientific thinking and social responsibility. The design and exploration of this paper show that the teaching design based on the history of chemistry is an effective way to improve the quality of high school chemistry, which is worthy of attention and popularization in high school chemistry education.

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