Occupation and Professional Education Vol. 2 No. 3, 2025

Aluminum and Aluminum Alloy Project-based Teaching: "Use Pepsi Cans to Make Aircraft Shells" as an Example

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Abstract: Taking Pepsi cans as the context line, carry out project-based teaching that can practically implement students' core literacy in chemistry. Determine the Pepsi cans to make airplane shells as the overall task, break down the overall task into 3 sub-tasks, and promote students to complete the 3 project sub-tasks based on the driving question progression. Students are allowed to complete the internalization of core knowledge related to the properties of aluminum and aluminum alloys in the process of solving real-world problems, and to transform the functional value of knowledge related to aluminum and aluminum alloys into chemistry core literacy.

Keywords: Aluminum and Aluminum Alloy; Driving Task; Project-Based Teaching; High School Chemistry; Chemistry Core Literacy

1. Introduction

The 2020 Revision of the Chemistry Curriculum Standards for General Senior Secondary Schools (2017) emphasizes the importance of "literacy-based" teaching, but promoting the development of students' core chemical literacy in disciplinary activities is a complex and continuous process, which needs to be implemented through long-term teaching and learning activities, implying that it is particularly important to carry out teaching and learning activities that can effectively promote students' core chemical literacy [1]. This means that it is particularly important to develop teaching activities that can effectively promote students' chemistry core literacy [1]. Teaching based on real problem situations to drive students to solve real problems is an important path to cultivate students' chemistry core literacy, but also an important platform for students to show the formed chemistry core literacy, and ultimately promote the gradual mastery of essential knowledge, skills and problem-solving ability in the process of disciplinary activities [2].

Project-based teaching can effectively promote the implementation of chemistry core literacy, which is conducive to students' continuous construction of cognitive thinking, deepen understanding of the concept of the discipline and enhance the ability to think in the discipline. Therefore, it is necessary to carry out project-based teaching, this project-based teaching to "aluminum and aluminum alloy" as the project content, through a systematic analysis of the project content, to the curriculum standards and project objectives as the benchmark, to determine the "Pepsi cans to make the shell of the aircraft" of the total project tasks, split the total task into two parts. The total project task is broken down into three sub-tasks: "Pepsi can appearance exploration", "Pepsi can material analysis" and "Pepsi can material processing". Tasks. Students are guided to master the contents of aluminum and aluminum alloy in the process of completing the tasks, thus highlighting the functional value of the knowledge related to aluminum and aluminum alloy, allowing students to actively explore knowledge in real situations, cultivating students' scientific inquiry ability and innovative consciousness, and structuring the knowledge and concepts of chemistry corresponding to aluminum and aluminum alloy as a whole. Teaching focuses on guiding students to recognize the extensive use of aluminum and aluminum alloys in life, gradually forming the concept of STSE [3], experiencing the charm of the chemical discipline, and then stimulating students' drive to learn chemistry. In the implementation of specific project-based teaching teaching process, focusing on guiding students to understand subject knowledge from multiple perspectives, such as material categories, element valence and "macro-micro-symbolic"

triple representation, the “nature determines the use of” core concepts in the learning content, to promote the effective integration of the development of core literacy, to promote the development of core literacy. The core concept of “nature determines use” is integrated into the learning content, which promotes the effective integration and development of core literacy [4].

2. Project-Based Teaching

Project-based teaching is a teaching activity based on the driving problem, guiding students to analyze the actual problem by calling on the core chemical knowledge experience and ideas that they have mastered, driving students to solve the actual problem independently with real-world problems, and prompting students to master the necessary knowledge experience for solving the actual problem and improve the problem-solving ability during the process of completing the specific project tasks [5]. Project-based teaching needs to be oriented to the curriculum standards and academic requirements, combined with the content of the textbook and students' existing knowledge and experience, to carry out teaching conducive to the development of students' core literacy. Project-based teaching needs to focus on the principles of the discipline and the concept of analyzing the problem as a whole, collecting and organizing a variety of information and using a variety of resources, through the way of inquiry activities to solve complex practical problems [6]. Project-based teaching consists of four elements: the knowledge content that students learn, the specific activities of students in the teaching process, the real situation that can drive students to complete the task, and the learning structure [7], and the problem-task line, the real situation line, the students' activity line, the teacher's guidance line, the knowledge line, and the line of evaluation of the literacy development line are the six basic guidelines of project-based teaching. The integration of contextualized project teaching is an effective path to carry out project-based teaching [8].

3. Project Content Theme Analysis

3.1 Analysis of Teaching Materials

Aluminum and aluminum alloy is the content of the Humanist version of high school chemistry, “Compulsory”, Book I, Chapter 3, Section 2, does not list aluminum as an important metal element to learn, emphasizing the enhancement of students' understanding of the metal element perspective and understanding of ideas. The textbook is mainly presented in the form of reactions between aluminum and oxygen, acids and bases, amphoteric oxides and composition of aluminum alloy materials, performance characteristics and uses, etc. Aluminum and alumina are analyzed in the form of experimental investigation of their properties by reacting with acids and bases, and it is concluded that alumina is an amphoteric oxide, but there is no in-depth discussion of the properties related to alumina and meta-alumina, which is shown in the following Figure 1. The content of this part of the old Hanyu Jiao Tong edition of the textbook increased the content of aluminum alloy, mainly about the value of aluminum alloy in production and life, to cultivate the development of students' scientific attitude and social responsibility of the core qualities of chemistry.

3.2 Analysis of Learning Situation

Junior high school chemistry has studied metal materials, students basically mastered the chemical properties of aluminum and oxygen, hydrochloric acid, dilute sulfuric acid reaction, the general properties of metal materials have a certain degree of understanding, such as metals have ductility, thermal conductivity and electrical conductivity [9]. In the study of this section of the content has been studied before the metal sodium, iron and related compounds, students have gradually formed “structure determines the nature, nature determines the use of” the concept of the chemical discipline, for the study of aluminum and aluminum alloy to provide the understanding of the perspective and understanding of ideas. Through the study of atomic structure, redox core concepts and the mastery of the method of learning chemical knowledge from the perspective of classification of substances, students can learn the properties of aluminum metal and amphoteric oxides from different perspectives and cognitive ideas, and can also grasp the relevant properties and applications of aluminum and aluminum alloys in production and daily life from the perspective of the triple characterization of

"macroscopic-microscopic-symbolic". In the production and life of the application, further constructed the students in the learning of subject knowledge and problem solving cognitive perspective and cognitive thinking.

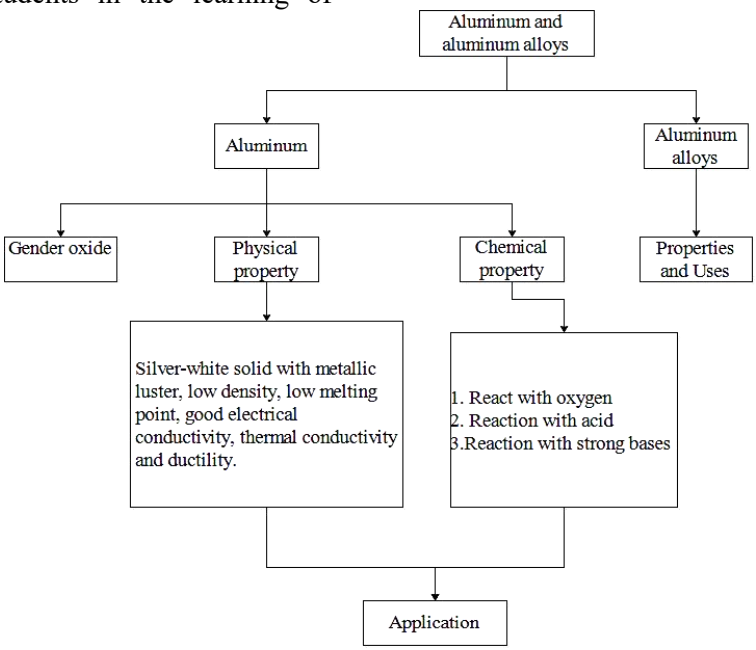

Figure 1. Aluminum and Aluminum Alloys Knowledge Points

4. Functional Value of Content and Project-based Teaching

4.1 Functional Value of Content

The standard requires that aluminum is not the same as iron, sodium metal as a key learning content, the part of the content is only as students learn to understand the object and perceptual understanding of the material, to promote students to have learned the conceptual knowledge and theoretical knowledge of the transfer of the application of problem solving, to help students to establish and develop the conceptual theory of the content of aluminum and aluminum alloys functional value of the content of the manifestation of the value. The study of the properties of aluminum establishes a perspective for the study of beryllium and zinc, which are also amphoteric substances. Aluminum is a transition metal element, which serves as a bridge between alkali metals, alkaline-earth metals and nonmetals, and establishes a bridge to the study of the Periodic Law of Elements in the transition from metals to nonmetals [10], which provides a support point for the students' understanding and mastery of the laws of the Periodic Law of Elements. The study of the properties and uses of aluminum alloys deepens the properties of alloys learned in junior high school and the related knowledge of titanium alloys learned earlier, and paves the way for the study of new alloys later.

4.2 Functional Value of Project-based Teaching

When students study aluminum and aluminum alloys, it is especially important for them to show their core chemical literacy and develop their core chemical literacy based on real problem situations and learning activities, which urgently requires "boarding" and "tasking" teaching and learning activities based on real situations for aluminum and aluminum alloys. This urgently requires "block" and "task-oriented" teaching activities based on real-life situations for the content related to aluminum and aluminum alloys. Project-based teaching activities can place students in real situations and guide them to complete driving project tasks, so as to master the concepts of the chemistry discipline, the core concepts and principles of the discipline, and the advanced development of literacy, which is in line with the cognitive logic of the students as well as the logic of the discipline of aluminum and aluminum alloys related contents. The contents of aluminum and aluminum alloy are closely connected with production, life, science and technology, and project teaching with driving

tasks is conducive to solving practical problems by organically combining the core concepts of chemistry of aluminum and aluminum alloy with science, technology, society and the environment, which can effectively integrate the teaching of aluminum and aluminum alloy with the concept of STSE education.

5. Project Teaching Objectives

(1) Through observing and analyzing the appearance of aluminum Pepsi cans to understand the physical properties of aluminum, students are guided to deepen the core concept of chemistry that properties determine uses from the perspective of the physical properties of aluminum [11].

(2) The material analysis of aluminum Pepsi cans, to understand the chemical properties of alumina, aluminum can react with acids and bases, the practical implementation of the core chemical literacy of students' macro-identification and micro-analysis, to enhance the ability to solve and analyze practical problems through experimental investigation, and to cultivate the enhancement of students' sense of scientific investigation and innovation.

(3) Through exploring the strategy of processing aluminum Pepsi cans into aircraft shells, understand the performance characteristics and uses of aluminum alloy materials, appreciate the role of chemistry in advancing the development process of human society, and promote the development of students' core literacy of scientific attitude and social responsibility.

6. Project Tasks and Teaching Process

Guided by the curriculum standards and project teaching objectives, this project-based teaching takes aluminum Pepsi cans as the context line. Students observe and analyze the appearance of Pepsi cans, as well as consult the information to determine the main chemical composition of Pepsi cans, to promote the mastery of the physical properties of aluminum in the process of completing the driving task, and at the same time to promote the students to contact the practical life to analyze the aluminum from the perspective of the nature determines the use. Uses; further put forward the Pepsi cans as a chemical material with what properties of the driving question, guide students to analyze the chemical properties of Pepsi cans through experimental investigation, in the process of investigation to achieve “macro - micro - symbols” triple characterization, so that students understand the chemical properties of aluminum, amphoteric oxides and other important content; finally, put forward the main chemical composition of Pepsi cans, promote students to complete the driving task in the process of mastering the physical properties of aluminum, and promote students to contact the actual life from the perspective of the nature of the use of aluminum analysis. Finally, the driving question of whether the materials of Pepsi cans can be used to make aircraft shells is raised, and students can understand the performance characteristics and uses of aluminum alloy materials in the process of thinking and exploring how to process Pepsi cans to make aircraft shells.

In summary, the general task of the project-based teaching can be identified as: “Pepsi cans to make aircraft shells”, the general task is broken down into three specific sub-tasks, prompting students to complete the process of driving sub-tasks, mastering the corresponding subject knowledge, the development of the corresponding core literacy in chemistry. The implementation process of the project is shown in Figure 2 below:

7. Project Specific Implementation Process

[Pre-course task] Students collect and organize the chemical composition of the Pepsi can material, as well as the manufacturing of aircraft shell on the material requirements.

[Introduction Context Line] Pepsi drinks can be found everywhere in our daily life, with plastic bottles and cans in two kinds of packaging, cans in the form of small, lightweight and beautiful packaging, as shown in Figure 3, easy to carry, can be recycled, low cost, to our lives has brought a lot of convenience. You usually use cans to do what, please talk about the actual life.

[Students] Talk about the interesting uses of cans.

[Teacher asks driving question] What is the material from which Pepsi cans are made, what are their properties, and can the material used to make Pepsi cans be used to make airplane shells?

[Teacher presents the driving general task]

Pepsi cans are used to make airplane shells.
[Teacher disassembles the master task] Task 1: Exploring the appearance of Pepsi cans; Task 2: Analyzing the materials of Pepsi cans; Task 3: Processing the materials of Pepsi cans.

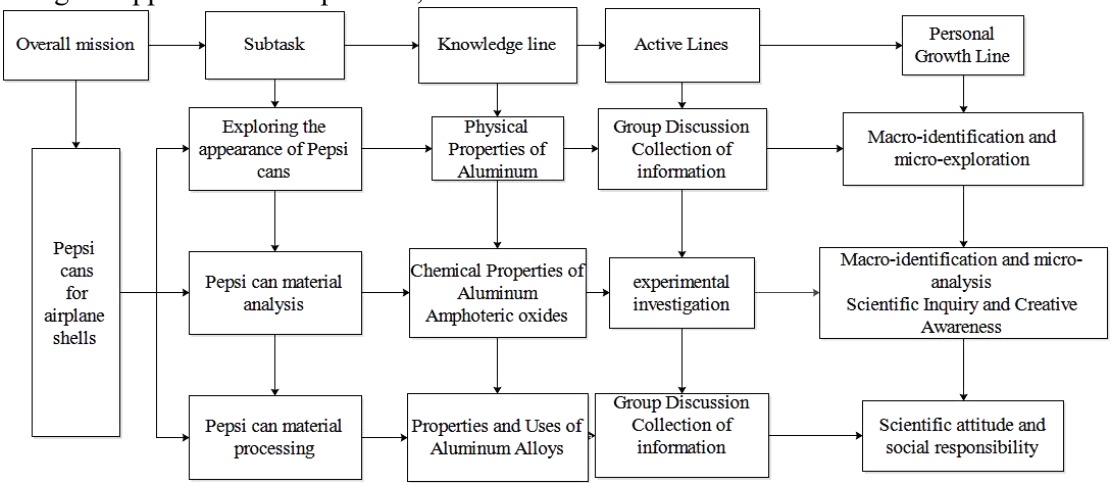

Figure 2. Project Implementation Flow

Figure 3. Pepsi Can Packaging

Session 1: physical properties of aluminum
[Assign Task 1] Explore the appearance of Pepsi cans.
Driving question] Pepsi cans are made of aluminum, observe the appearance of Pepsi cans and from the perspective of the core concept of "categories of substances" in relation to the knowledge of metal materials, analyze what physical properties of aluminum?
[Student Group Discussion and Reporting] According to the appearance of aluminum Pepsi cans and the properties of metallic materials, aluminum is a silvery-white solid with a metallic luster, and has the properties of metallic materials, such as ductility, electrical conductivity, and thermal conductivity.
[Teacher's summary] In addition to aluminum Pepsi cans, aluminum is widely used in daily life, according to the physical properties of aluminum, which has electrical conductivity determines that aluminum can make wires, cables; thermal conductivity determines that it can make food and beverage pots and pans. Aluminum in the earth's crust is high, is the most abundant metal element in the earth's crust, so aluminum products are more common and cheap.
Session 2: the chemical properties of aluminum and amphoteric oxides
[Assign Task 2] Analyze the materials of Pepsi cans.
[Driving Question] The material of Pepsi cans is made of aluminum. Work in groups to design experiments to investigate the chemical properties of aluminum.
[Students work in small groups to investigate experimentally]
Take the Pepsi cans of two materials for grinding to remove the oxide film on the surface of aluminum, respectively, to explore whether it can react with hydrochloric acid, sodium hydroxide, the specific content of the investigation is shown in Table 1 below:

[Teacher] From the perspective of elemental valence, link the conceptual principles of redox disciplines learned earlier to analyze the chemical properties of aluminum.
[Student]Aluminum monomers have a valence of 0. The low valence is reductive, and their properties are active and can be oxidized by oxygen at room temperature, $4Al+3O_2=2Al_2O_3$.
[Ask the driving question] Aluminum placed in air forms a dense oxide film, which is corrosion-resistant and protects the internal metal from corrosion. Can the oxide film on the surface of aluminum react with acids and bases?
[Students work in small groups to investigate experimentally] Take 2 pieces of Pepsi cans, respectively, to investigate whether it can react

with hydrochloric acid, sodium hydroxide, the specific process shown in Table 2:

[Teacher's summary] Through the investigation experiment, aluminum and the protective film on the surface of aluminum can react with acid and alkali, Al2O3 can react with both acid and alkali, the substance with this chemical property is called amphoteric oxide. Aluminum tableware can be found everywhere in daily life, such as aluminum cookware, but because Al and Al2O3 can react with acids and alkalis chemical properties, so aluminum cookware can not hold or steam acidic and alkaline food.

Session 3: Properties and Uses of Aluminum Alloys

Table 1. Investigating the Reaction of Aluminum with Acids and Strong Bases

Experimental Investigation 1	react with acid	react with bases
experimental step	Take 6 mL of HCl in a test tube, then drop a small piece of Pepsi can aluminum flake which has been polished to remove the oxide film into the test tube, and leave it to react for some time, and place a lighted wooden strip at the mouth of the test tube. 	Take 6 mL of NaOH in a test tube, then drop a small piece of Pepsi can aluminum flake which has been polished to remove the oxide film into the test tube, and leave it to react for some time, then place a lit wooden strip at the mouth of the test tube. 
Experimental Phenomena	A slight popping sound can be heard and bubbles are immediately produced.	
Chemical symbol characterization	$Al+6HCl=2AlCl_3+3H_2\uparrow$	$2Al+2NaOH+2H_2O=2NaAlO_2+3H_2\uparrow$
Conclusion of the experiment	Aluminum reacts with both acids and bases.	

Table 2. Investigating the Reaction of Aluminum Oxide with Acids and Strong Bases

Experimental Investigation 1	react with acid	react with bases
experimental step	Take 6.00mL of HCl in a test tube and drop a small piece of unpolished Pepsi can material into the test tube to remove the oxide film. 	Take 6.00 mL of NaOH in a test tube and drop a small piece of unpolished Pepsi can material to remove the oxide film into the test tube. 
Experimental Phenomena	After a period of reaction, bubbles were produced and the Pepsi can material dissolved.	
Chemical symbol characterization	$Al_2O_3+6HCl=2AlCl_3+3H_2O$	$Al_2O_3+2NaOH=2NaAlO_2+H_2O$
Conclusion of the experiment	The protective film on the surface of aluminum can react with acids and alkalis.	

[Task 3] Pepsi can material processing.

[Driving question] We have learned the physical and chemical properties of aluminum, what kind of properties are needed for aircraft shell materials? Pepsi can material how can be made of aircraft shell?

[Students collect and organize information] aircraft shell materials need to have the nature

of: corrosion resistance, low density and mechanical strength, can resist the impact of strong air currents, hardness.

[Teacher Question] Aluminum Pepsi material texture is soft, corrosion resistance degree is not strong enough and hardness is not strong enough to make the aircraft shell, how to Pepsi can material processing to be made into a good performance of the aircraft shell material?

[Student Group Discussion] Pepsi cans will be processed into aluminum alloy materials.

[Teacher Summary] To make the Pepsi cans into an aircraft shell, the need to add 4% of the copper, 0.5% of the magnesium and manganese in aluminum, 0.7% of the silicon, can be made into a suitable aircraft shell material of aluminum alloy, this aluminum alloy is called duralumin.

[Teacher Question] What are the properties of alloys? How to make alloys?

[Student Review] Alloys are hard, corrosion resistant, strong and have better properties than pure metals [12]. A metal can be made into an alloy by heating it and fusing it with other non-metals or metals. Aluminum can be made into an aluminum alloy by heating it and fusing it with other metals.

[Teacher follow-up question] What are the uses of aluminum alloys in life?

[Student Answer] Aluminum alloys are used to make airplane shells, rockets, ships, windows, doors, and other materials.

[Teacher's summary] In the aluminum to add a small amount of alloying elements can be made of aluminum alloy, such as copper, magnesium and rare earth elements, aluminum alloy density is small, high strength, good performance. Aluminum alloy is widely used in production and life. Such as construction, electromechanical, catering, shipping, aviation and transportation and other fields [13].

[Teacher's summary] Through the study of this lesson, we have learned the properties of aluminum and aluminum alloy, both of which are widely used in our lives, which once again shows that chemistry is closely related to our lives, so we should apply the chemical knowledge we have learned to solve practical problems in social production and life, to promote social progress and the development of science and technology, and to manifest the functional value of the core knowledge of chemistry.

8. Summarize

Aluminum and aluminum alloy content, carry out project-based teaching with systematic, holistic and logical, connect the knowledge points of metal materials and alloys in junior high school with the relevant content of aluminum and aluminum alloy across the school segments, so that the students can master the relevant knowledge points of aluminum and aluminum alloy on the basis of their existing knowledge and experience. Based on the teaching idea of project-based teaching, the reasonable design and implementation of driving questions, trying to enhance the students' ability to find problems, raise questions, and effectively support the implementation of the project tasks , the project teaching selected “Pepsi cans to make the aircraft shell” on the content of aluminum and aluminum alloy learning, students in the solution of real situations In the process of solving the real situation, the students pay attention to the transfer and application of the core knowledge of chemistry and the ability to extract information to analyze and solve problems. In addition, the project-based teaching is closely connected with life, focusing on the organic integration of the knowledge of aluminum and aluminum alloy and STSE knowledge, prompting students to appreciate the important value of aluminum and aluminum alloy in the production and life of the society, transforming the mastered knowledge of aluminum and aluminum alloy, disciplinary concepts and disciplinary thinking into problem-solving ability, forming the core chemical literacy of scientific attitude and social responsibility, and stimulating the motivation of students to learn chemistry and apply chemical knowledge. The core quality of chemistry is formed with scientific attitude and social responsibility, and students are motivated to learn chemistry and apply chemistry knowledge. Carrying out project teaching of aluminum and aluminum alloy is a renewed construction of the subject knowledge, concepts, perspectives and thinking corresponding to metal materials and alloys, focusing on helping students to form the core concept of “nature determines use”, enhancing students' understanding of substances and chemical changes, and highlighting the timeliness and value of project teaching activities and value of the project teaching

activities.

References

[1] Developed by the Ministry of Education of the People's Republic of China. Chemistry curriculum standard for general high school (2017 edition revised in 2020). Beijing: People's Education Press, 2020.

[2] Han Xiao; Jiang Hepei; Dynasty Hui. Project-based teaching based on real situations--The purification of crude silicon and its principles as an example. Chemistry Teaching, 2020, (04): 46-50.

[3] WU Xiaobit; HE Yuqing; SUN Zehao. Project-based learning of "comprehensive utilization of starch". Chemistry Education (in Chinese and English), 2023, (05): 39-47.

[4] Wang Lei. Based on the concept of multi-dimensional curriculum content, the core literacy development requirements of the external learning theme - the focus of the revision of the curriculum content of the compulsory education chemistry curriculum standard. Teaching Materials. Teaching Methods, 2022, 42(08): 47-54.

[5] Hu Hongxing. Project-based learning: A classroom teaching activity to cultivate students' core literacy. Journal of Lanzhou University (Social Science Edition), 2017, 45(06): 165-172.

[6] Liu Jingfu; Zhong Zhixian. Research on project-based learning (PBL) model. Foreign Education Research, 2002, (11): 18-22.

[7] Xiang Hongying. Practical Research on Project-based Learning in Chemistry Teaching. Chemistry Education (in Chinese and English), 2022, (16): 61-64.

[8] WANG Lei; HU Jiuhua; WEI Rui; ZHAO Yannan. Research on the curriculum, teaching and evaluation system of project-based learning in chemistry - 20 years of research history and results of the chemistry education research team of Beijing Normal University. Chemistry Education (in Chinese and English), 2022, (16): 24-29.

[9] Gao Min; Miao Chunyu; Shang Li Jing; Li Bing. Contextual teaching based on the concept of STSE education--taking "aluminum and aluminum alloy" as an example. Middle School Chemistry Teaching Reference, 2023, (03): 19-21.

[10] Li Fashun. Developing students' thinking to match the logic of evidence--Talking about the teaching value and thinking of "Aluminum and Aluminum Alloy". Secondary school chemistry teaching reference, 2022, (15): 18-21.

[11] Li Junda; Liu Zhongying. Teaching the use of metallic materials in the context of promoting the space dream - the use of aluminum and aluminum alloys. Chemistry Education (in Chinese and English), 2023, (13): 43-48.

[12] Li Lei. Teaching design of "metallic materials". Chemical Education, 2010, (S2):4 2-44.

[13] Cao, Manli; Liu, Wenting; Zhang, Xiulian. Exploration and practice of material chemistry course on ideology and politics--Taking "common metal materials" as an example. Chemistry Education (in Chinese and English), 2021, (24): 27-34.