Applied Research on Problem-Driven Teaching in The Teaching of Important Iron Compounds

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Abstract. With the continuous deepening of educational reform, cultivating students' core literacy has become an important goal of high school chemistry teaching. This study explores the application of problem-driven teaching in the teaching of "an important compound of iron" in high school chemistry. By designing problem situations, implementing teaching strategies and evaluating teaching effects, comparing traditional teaching methods, and analyzing students' learning effects and changes in attitudes, it is found that problem-driven teaching can effectively improve students' learning interest, understanding depth and problem-solving ability. Teaching practice shows that this method helps students take the initiative to build a knowledge system, cultivate the spirit of scientific inquiry, and provide new ideas and methods for the reform of high school chemistry teaching. This study aims to explore the application of problem-driven teaching in the teaching of important compounds of iron, design corresponding teaching strategies, and evaluate its effect. Through literature research, teaching practice and effect evaluation.

Keywords: problem-driven teaching; important iron compounds; teaching strategies; scientific exploration

1 Introduction

As a student-centered teaching method, problem-driven teaching emphasizes the promotion of students' in-depth learning and thinking development by asking questions, analyzing problems and solving problems. The important compound of iron is an important part of high school chemistry courses, which involves the properties, preparation and application of iron oxides, hydroxides, salts and other compounds. Traditional teaching methods are often based on teachers' explanation and students passively accepting knowledge, which is difficult to stimulate learning interest and in-depth understanding. As a student-centered teaching method, problem-driven teaching helps to improve the teaching effect by creating problem situations and guiding students to take the initiative to explore and solve problems.

This study aims to provide reference for the reform of high school chemistry teaching, offer an effective teaching strategy to high school chemistry teachers, and supply

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chemistry education research with new perspectives and practical cases, which can promote the development of students' core chemistry literacy.

2 The Theorical Basic of Problem-Driven Teaching

Problem-driven teaching is a problem-oriented and student-centered teaching method. PBL transforms the traditional teacher-centered approach to student-centered approach, thereby emphasizing on the necessity for student's participation in the discussion[7]. It is characterized by emphasizing the main position of students, encouraging students to take the initiative to explore and build knowledge, and cultivating critical thinking and problem-solving ability. Its theoretical foundation mainly includes constructivist learning theory, inquiry-based learning theory and situational learning theory Problem-driven teaching promotes the migration and application of knowledge by designing real problem situations. It promotes the development of students' communication and cooperation ability and independent learning ability[1].

In chemistry teaching, problem-driven teaching has unique advantages. First of all, it meets the requirements of the new curriculum reform and can promote the development of students' core literacy. Secondly, the subject of chemistry itself is exploratory and practical, which is highly associated with the concept of problem-driven teaching. By designing appropriate chemical problems, students can be guided to conduct scientific exploration and cultivate their experimental design and data analysis ability. In addition, problem-driven teaching can also help students establish a connection between chemical knowledge and real life, and improve the application ability of knowledge.

Chemistry is an experiment-based science, and many chemical concepts and principles can be presented through problem situations. By designing appropriate chemistry questions, it can stimulate students' interest in learning and guide them to take the initiative to observe, think and experiment, so as to deeply understand chemical knowledge and cultivate scientific inquiry ability.

Experiment is an important part of the knowledge system of secondary school chemistry, and at the same time, experiment is also an important method and means of teaching the chemistry subject at the secondary school level. With the deepening of the curriculum reform, the requirements faced by the chemistry classroom have gradually increased, and the "Chemistry Curriculum Standards for Compulsory Education (2022 Edition)" suggests that the core literacy should be prioritized, and that chemistry experiments should be used as an effective means to enhance students' scientific thinking and innovative spirit. The Chemistry Curriculum Standard for General High Schools (2017 Edition Revised in 2020) also puts forward targeted and guiding requirements for chemistry laboratory teaching in secondary schools, and takes chemistry experiments as an important way and method to cultivate students' core literacy in the discipline of chemistry can also foster a sense of creativity in students.Students take the initiative to participate in the experimental process, discover problems, put forward hypotheses, design experimental schemes, collect and analyze data, and finally draw conclusions through practical exploration. Such a teaching method can help students form a positive and active learning attitude, stimulate their enthusiasm for exploring the unknown, and then cultivate their innovative thinking and practical ability.

3 Analysis of The Teaching Content of Important Iron Compounds

The important compounds of iron mainly include iron oxides, hydroxides and salts. Among iron oxides, FeO, Fe_2O_3 and Fe_3O_4 are the three most common, with different colors, stability and magnetism. Iron hydroxides include $Fe(OH)_2$ and $Fe(OH)_3$. The former is easily oxidized into the latter, reflecting the variable valence characteristics of iron. Among iron salts, $FeSO_4$ and $FeCl_3$ are typical representatives. Their hydrolysis reaction and color change in aqueous solution are the focus of teaching.

These compounds are not only widely used in daily life and industrial production, but also important carriers for understanding chemical principles such as redox reactions and ion reactions. For example, Fe_2O_3 is used as a pigment and catalyst, Fe_3O_4 is used to make tapes and disks, $FeSO_4$ is used in water treatment and medicine, and $FeCl_3$ is used in sewage treatment and printed circuit board manufacturing. Through practical application, it can enhance students' interest in learning and deepen their understanding of knowledge.

At present, the main problems in the teaching of iron's important compounds are as follows: First, the teaching method is single[6]. Secondly, the teaching content is not closely related to actual life. In addition, the experimental teaching link is weak. Finally, the evaluation method focuses too much on mechanical knowledge memory and ignores the cultivation of students' thinking process and problem-solving ability. These problems restrict students' in-depth understanding of the important compounds of iron and the improvement of their application ability. Therefore, these difficulties can be solved by designing appropriate problem situations to guide students through experimental observation and theoretical analysis.

4 Teaching Design of Important Compounds Based on Problem-Driven Iron

The teaching design of important compounds based on problem-driven iron mainly includes problem situation design, teaching process design and student activity design. The "concept of transformation" emphasizes the dynamic process of material changes, which is the foundation of chemical research and application. By understanding the transformation process of iron and its compounds, we can better control chemical reactions[4]. For example, a series of hierarchical problem chains can be designed according to the teaching objectives and students' cognitive level. The following problem situations can also be designed: "Why do iron nails rust in a humid environment? What happened to the iron compound during the rusting process? How to prevent iron products from rusting?" These problems link the properties of iron compounds with the phenomena in real life, stimulating students' desire to explore. Therefore, it is necessary to pay attention to the creation of real situations and the design of problem chains while teaching, and let students experience the exploration process of solving practical problems in a progressive way while learning[2]. The design of the teaching process should follow the basic model of "asking questions - analyzing problems - solving problems - summarizing and reflecting". First, lead in problems through demonstration experiments or life examples; then, guide students to analyze problems and put forward hypotheses; then, verify hypotheses through experimental exploration or theoretical analysis to solve problems; finally, summarize the knowledge points and reflect on the learning process.

By constructing a two-dimensional diagram of "valence-category", students are guided to analyze the properties of substances from the perspectives of the classification concept, the change concept, etc., to solve real problems, to form chemical concepts such as the element concept and the change concept, and to implement the integration of "teaching, learning and assessment"[3]. For example, during the teaching of iron hydroxide, firstly, demonstrate the color change of $Fe(OH)_2$ to $Fe(OH)_3$, which leads in the question: "Why does the white precipitate turn reddish brown?" Then, guide students to analyze the valence changes of iron and verify the reducibility of $Fe(OH)_2$ through experiments.

Comics and comic zines have been shown to be attractive media forms for presenting information to students in an easily digestible form[7]. The design of student activities should focus on cultivating students' scientific exploration ability. Cooperative experiments in groups can be designed to let students personally prepare iron compounds and observe the changes in properties. For example, designing experiment to explore the effect of the reaction conditions of $FeSO_4$ solution and NaOH solution on the color of the product can guide students to think about the oxidation process of $Fe(OH)_2$. Open questions can also be designed to encourage students to consult information and explore the application of iron compounds in environmental protection, energy development and other fields.

With the development of Internet information technology, the empowering effect of the Internet on education has become more and more obvious. Both the new junior high school curriculum and the new senior high school curriculum have repeatedly and explicitly mentioned the development of digital experiments in conjunction with information technology, affirming its important value for chemistry teaching. As a means of teaching in line with the development of the times, information technology allows students to carry out scientific investigation in experimental activities, and on the basis of promoting a deep understanding of the content learned, they can also feel the important value of technological advances and innovations in the science of chemistry, forming a rigorous, realistic and practical scientific attitude, and further implementing the development of the core qualities of the discipline of chemistry. Reasonable use of information technology can not only enhance teaching efficiency and assist in experimental operations, but also effectively stimulate students' interest in learning.

5 Teaching Implementation and Effect Evaluation

The chemistry classroom emerged as a dynamic space where intricate scientific thinking unfolded during this experience, and our embodied, multimodal analysis focused on unraveling this complexity[6]. In the process of teaching implementation, teachers should pay attention to guiding students to think actively and encourage students to ask questions. For example, in the teaching of iron oxides, students can observe the color and magnetism of different iron oxides and raise questions about their structure and properties. In the experimental link, teachers should guide students to standardize the operation and cultivate a rigorous scientific attitude. At the same time, multimedia technology is used to display the micro-reaction process to help students understand abstract concepts.

Diversified methods should be adopted for the evaluation of teaching effects. Understand students' interest in learning and participation through classroom observation, student interviews and questionnaires. Design knowledge test questions to assess students' mastery of iron's knowledge of important compounds[7]. For example, multiple-choice questions can be designed to test students' understanding of different valence states of iron, and experimental questions can be designed to test students' ability of experimental operation and phenomenon analysis. In addition, students' problem-solving ability and scientific exploration ability can also be evaluated in the form of group reports or small papers.

Driven by real problems, the knowledge in the textbooks is connected with real life, and emphasis is placed on the development of students' higher-order thinking abilities[5]. The evaluation results show that problem-driven teaching can effectively improve students' interest in learning and depth of understanding. The results of the knowledge test show that students' mastery of the properties and applications of important iron compounds has been significantly improved. The ability of experimental operation and phenomenon analysis has also improved significantly, and he can use the knowledge learned to explain chemical phenomena in life.

6 Conclusion

This study explores the application of problem-driven teaching in the teaching of "important compounds of iron" in high school chemistry. Research has found that problem-driven teaching can effectively improve students' learning interest, understanding depth and problem-solving ability by designing problem situations, implementing teaching strategies and evaluating teaching effects. Teaching practice shows that this method helps students take the initiative to build a knowledge system and cultivate a spirit of scientific inquiry.

In the process of chemistry laboratory teaching in secondary school, teachers need to focus on guiding students to understand chemical knowledge at a deeper level, and also need to cultivate students' hands-on practical ability, and strive to improve students' core literacy. In this process, teachers should focus on guiding students to think independently and design and complete experiments on their own. In addition, teachers should add interesting exploratory experimental activities in the classroom teaching process to deeply stimulate students' enthusiasm for participating in chemistry learning activities, continuously enhance their learning ability, and improve students' core literacy.

However, the implementation of problem-driven teaching also faces some challenges, such as grasping the difficulty of problem design and the reasonable allocation of class time. Future research can further explore the organic combination of problem-driven teaching with other teaching methods, develop more high-quality teaching resources and cases, and provide more references for the reform of high school chemistry teaching.

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