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# High School Chemistry Teaching Case Design Based on Discovery Learning Theory

**Li Lele[1], LONG Shijia[*], LIU Aimin[2], FENG Ziyi[3], LI Xiaofang[4]**

*Tianshui Normal University, Tianshui City, Gansu Province 741001, China*

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C/A: LONG Shijia[2]

**Abstract:** Discovery learning theory is an important theory advocated in the field of pedagogy at present, which fully embodies the teaching concept of "student-oriented". Based on discovery learning theory, this paper studies the case design of chemistry teaching in senior high school. The concept and characteristics of discovery learning are summarized. The teaching mode of chemistry under discovery learning theory is explored. In order to promote the development of students' thinking ability and the effective achievement of the core quality of chemistry, the teaching case design based on chemical discovery learning teaching mode is carried out to cultivate innovative talents for the new era.

**Keywords:** Discovery learning, High school chemistry

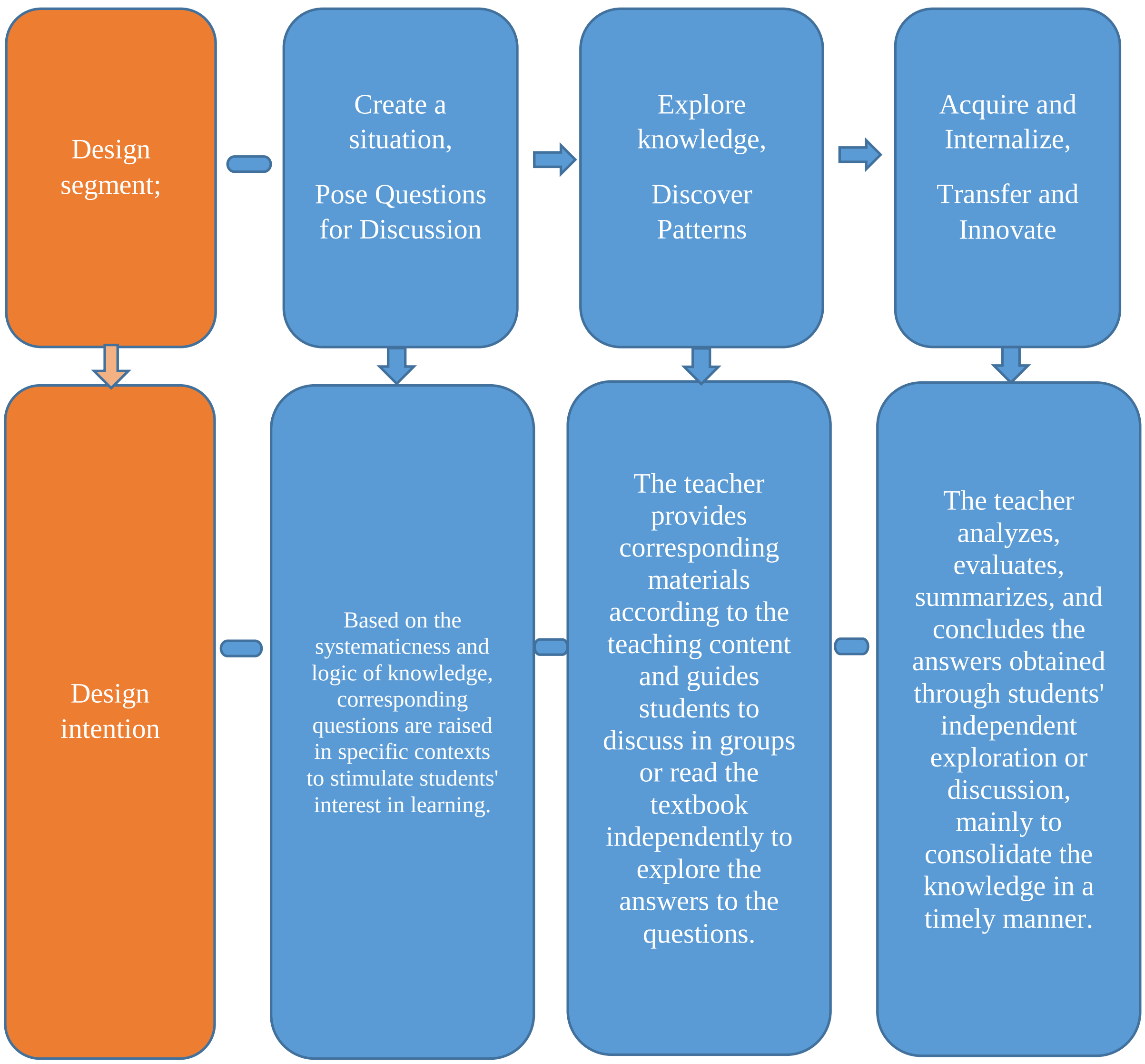
Chemistry is an important branch of natural science and plays a vital role in national development. The General High School Chemistry Curriculum Standards (2017 Edition, Revised in 2020) clearly states that, in accordance with the cognitive development laws and developmental needs of high school students, the high school curriculum should further enhance students' abilities to identify, analyze, and solve problems. High school students are characterized by being "curious," "inquisitive," and "active." The discovery learning theory happens to cater to these psychological traits of high school students. By guiding students to identify problems, it stimulates their curiosity, arouses their desire to ask questions, and prompts them to discover the laws of knowledge; effectively mobilizes students' initiative in learning; and fulfills students' desire to be active by actively participating in teaching interactions, helping students discover truths. Therefore, the discovery learning method is conducive to cultivating students' intrinsic motivation for learning, intuitive thinking, and innovative thinking [1].

## 1.THE MEANING OF DISCOVERY LEARNING THEORY

The discovery learning theory proposed by Bruner, advocates that teachers should create authentic and concrete teaching situations to guide students in exploring academic knowledge and constructing a knowledge system, rather than indoctrinating students with ready-made knowledge for them to memorize. The discovery learning method refers to all methods by which students personally acquire knowledge using their own minds [2]. It mainly has four characteristics: (1) It emphasizes that students are the subjects of learning in the learning process, and teachers provide authentic learning situations; (2) It emphasizes the driving force of students' learning, and the discovery learning method can effectively stimulate students' curiosity about learning, generating intrinsic motivation for learning; (3) It emphasizes cultivating students' intuitive thinking, which is the foundation for cultivating innovative thinking; (4) It emphasizes the retrieval of knowledge, as only by retrieving knowledge can it be effectively acquired, internalized, transferred, and applied [3].

## 2.THE MODEL OF DISCOVERY LEARNING THEORY

Chemistry primarily focuses on the composition, structure, properties, and applications of matter, playing a significant role in the development of human society. However, due to the abundance of high school teaching content, limited class hours, and the heavy workload of teachers, there is an emphasis on conclusions over processes, leading students to engage in "rote learning" and "passive reading." Currently, education is still heavily focused on "exam-oriented education," with many schools emphasizing enrollment rates and requiring teachers to complete teaching tasks and improve teaching quality. Therefore, teachers tend to instill knowledge into students through rote instruction and mechanical training to fulfill their teaching responsibilities, which hinders the development of students' thinking abilities [4]. Nevertheless, based on the characteristics of the discovery learning theory, designing high school chemistry lessons centered around students through this theory can enhance their thinking abilities and effectively promote the achievement of core competency goals. By reviewing numerous literatures, the author has summarized several key stages of the discovery learning model, as illustrated in the following diagram [5].



## 3. DESIGN OF A TEACHING CASE BASED ON THE DISCOVERY LEARNING MODEL

### 3.1 Properties of Sodium

**Section 1: Create a Situation, Pose Questions for Discussion**

The teacher provides students with sodium stored in kerosene, alcohol lamps, water, etc. The teacher demonstrates how to obtain and cut sodium and places a piece of sodium, the size of a soybean, on the wick of an alcohol lamp. Students are guided to perform the experiment of "lighting a lamp with a drop of water" by using a dropper to add a single drop of water onto the wick of the alcohol lamp, which then ignites. The teacher asks questions such as: Why is sodium stored in kerosene? Why can kerosene store sodium? Why isn't sodium stored in water? What other substitutes can be chosen? What factors need to be considered when selecting substitutes?

**Design Intent:** Using the teacher-student demonstration experiment as an entry point, a real teaching situation is created to help students understand the properties of sodium, stimulate their interest in learning, further raise questions, and motivate students' intrinsic motivation for learning.

**Section 2: Exploring Knowledge and Discovering Patterns**

The teacher guides students to discuss in small groups, focusing on the reactivity of sodium and the properties of kerosene, gasoline, and carbon tetrachloride, to discuss the storage conditions for sodium. The following materials are provided to students to further guide them to actively explore the above questions and find the answers.

**Table 1** The properties of matter are as follows

| Matter | Boiling Point | Comprise | Density |
|---|---|---|---|
| Kerosene | 180-310℃ | $C_{11}$-$C_{18}$ | 0.8 |
| Gasoline | 220℃ | $C_5$-$C_{11}$ | 0.7 |
| Seretin | 76.5℃ | $CCl_4$ | 1.594 |

**Teacher:** Guide students to explore the properties of sodium and kerosene by examining the composition, boiling points, and densities of kerosene, gasoline, and carbon tetrachloride. First, lead students to discuss and identify the similarities and differences among these three substances.

**Student 1**: The similarity is that they are all organic solvents; the differences lie in their densities, boiling points, and compositions.

**Teacher:** Guide students to observe the patterns in their densities, boiling points, and compositions.

**Student 2**: The boiling points of kerosene, gasoline, and carbon tetrachloride decrease sequentially, while their densities increase. The number of carbon atoms in their compositions decreases as well.

**Teacher:** First, we must consider chemical compatibility. Sodium is highly reactive and easily reacts with oxygen and water vapor in the air, so the storage medium needs to isolate air. Next, let's analyze density. Kerosene has a lower density than sodium, meaning sodium will sink in kerosene. Gasoline also has a lower density than sodium, but its volatility and flammability pose safety hazards. Carbon tetrachloride has a higher density than sodium, causing sodium to float above it, unable to isolate air, and thus unsuitable as a storage medium. Finally, considering boiling points and compositions, kerosene has a higher boiling point and contains more carbon atoms, enhancing intermolecular forces and making it relatively stable at room temperature. Through the above analysis, kerosene is the most ideal storage medium for sodium compared to the other two.

**Teacher:** Students, think about what factors we should consider when selecting an alternative storage medium for sodium.

**Student 3:** Density, boiling point, and safety.

**Teacher:** Based on the above analysis, when selecting an alternative storage medium, compatibility and density should be prioritized to ensure sodium can be safely stored in the medium. Additionally, factors such as the medium's boiling point, volatility, safety, and cost also need to be considered.

**Design Intent:** The teacher has clear teaching objectives, guiding students to engage in autonomous learning and explore the properties of sodium based on their existing cognitive structures. In actual teaching, the teacher inspires students to read the textbook or provided materials multiple times and think about problems from multiple angles, cultivating their abilities to analyze and solve problems. This is conducive to effectively achieving the core literacy goals of chemistry, including "scientific inquiry and innovation awareness" and "scientific spirit and social responsibility."

**Section 3: Acquire and Internalize, Transfer and Innovate**

The teacher analyzes and evaluates the students' answers, summarizing the physical properties of sodium and kerosene, as well as the factors to consider when selecting a reagent for storing sodium.

**Design Intent:** By analyzing and evaluating the properties of sodium and kerosene summarized by students, the teacher employs flexible and diverse teaching methods and techniques to accurately reveal the shortcomings and deficiencies in students' autonomous learning process. The teacher then guides students to reasonably summarize and comprehend the essence of scientific knowledge, fostering innovative thinking. This enables students to apply their learned knowledge to analyze and solve practical problems when encountered, thereby cultivating their core competencies in chemistry.

## 3.2 Reaction of Sodium with Water

**Section 1: Create a Situation, Pose Questions for Discussion**

The teacher takes a beaker, adds water to it, and drops a few drops of phenolphthalein. A sodium piece of soybean-sized is then added to the water, and the phenomena are observed. Students are prompted to think about the following questions: Where does the sodium piece lie in the water after being added? What does this indicate? How does the state of sodium change? How does sodium move? What color change occurs in the phenolphthalein-dropped solution? Can an experiment be designed to prove what gas is produced? What do these phenomena reveal? How should a sodium fire be extinguished?

**Design Intent:** With experimental phenomena as the starting point, a realistic teaching situation is created. By posing relevant questions, students are encouraged to actively think about the reaction phenomena between sodium and water, stimulating their interest in learning and enhancing their classroom participation. This creates a favorable classroom atmosphere and cultivates students' divergent thinking abilities, enabling them to effectively apply their learned knowledge to solve practical problems.

**Section 2: Exploring Knowledge and Discovering Patterns**

**Teacher:** Let students take a sodium piece of bean-sized (the teacher informs students beforehand about the proper way to handle sodium). The teacher guides students to conduct experiments and observe the phenomena of sodium reacting in water. Students actively explore, engage in group discussions, analyze, and summarize the above questions. They identify the changes that occur when sodium reacts with water, what gas is produced, and how to handle a sodium fire.

**Student 1:** Sodium floats on water, melts into a small ball, emits a sizzling sound, and the solution turns red.

**Teacher:** The teacher guides the students to analyze and summarize. Sodium has a lower density than water, so it floats on the surface; sodium has a low melting point and reacts with water to release a large amount of heat, causing the sodium to melt into a shiny ball floating on the water; the vigorous reaction between sodium and water results in the rapid escape of gas, producing a sizzling sound; the solution turns red because the sodium reacts with water to produce sodium hydroxide, which is alkaline and turns phenolphthalein red.

**Teacher:** Let's discuss and guess what gas is produced.

**Student 2**: Based on the conservation of elements before and after the reaction, it should be hydrogen.

**Teacher:** How can we test it? Please think about it.

**Student 3:** Collect the gas produced during the reaction in a test tube. The gas will burn quietly with a pale blue flame. (If a glass tube is used, the flame may appear yellow.)

Teacher's supplement: Sodium reacts with water to produce hydrogen. Therefore, before igniting hydrogen, it needs to be tested for purity, and the collected gas should be kept away from open flames.

**Teacher:** What should we do if sodium catches fire? Can we use water to extinguish it?

**Student 4:** No. Because sodium reacts with water, we should use sand for extinguishing.

**Teacher:** Through the reaction of sodium with water, students have learned about the phenomena of sodium's reaction with water and that water cannot be used to extinguish a sodium fire.

**Design Intent:** The teacher guides students to explore the reaction of sodium with water independently based on their previous knowledge, inspiring them to observe, analyze, think, and solve problems from multiple perspectives, thereby obtaining the laws of material changes. This promotes the development of students' intuitive, imagery, and abstract thinking abilities and facilitates the effective achievement of chemical subject core literacy goals such as "macroscopic identification and microscopic analysis" and "scientific inquiry and innovation awareness".

**Section 3: Acquire and Internalize, Transfer and Innovate**

Groups present their discussion results, and the teacher analyzes and evaluates the students' findings, summarizing the phenomena of sodium's reaction with water and how to extinguish a sodium fire. The teacher consolidates the knowledge points of this lesson, establishes a knowledge structure system, and cultivates students' ability to summarize and analyze.

**Design Intent:** By analyzing and evaluating the students' summaries of the phenomena of sodium's reaction with water, the teacher skillfully uses teaching wisdom and strategies to precisely point out the deficiencies in students' autonomous learning process. The teacher then guides students to self-reflect, reasonably internalize and integrate knowledge, and achieve learning by analogy. This process not only promotes students' understanding of knowledge but also cultivates their rigorous and factual scientific attitude.

## CONCLUSION

The "Discovery Learning Theory" consistently adheres to a student-centered perspective, transforming the role of teachers into guides and collaborators in the learning process of students. This shift in teacher roles, when applied in chemistry instruction through the "discovery learning" model, stimulates students' initiative and effectively mitigates the occurrence of "spoon-feeding" teaching methods. It aligns well with the psychological characteristics of middle school students, who are curious, active, and inquisitive [6]. Based on the current teaching situation in middle schools and the characteristics of the discovery learning theory, this paper designs corresponding teaching models and relevant instructional case studies. Starting with questions rooted in daily life, intellectual challenges, and skill-oriented problems, it leverages the advantages of problem-based learning by encouraging independent thinking among students. This approach ignites their desire to explore and fosters their enjoyment of learning. It not only cultivates students' abilities to actively explore, discover, analyze, and solve practical problems but also promotes the development of their intuitive and innovative thinking, effectively implementing the core competencies of chemistry education.

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