DEVELOPMENT AND TEACHING APPLICATION OF SECONDARY SCHOOL CHEMISTRY TEACHING RESOURCES BASED ON NOBEL PRIZE CASES

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ABSTRACT

With the advent of the knowledge-based economy, the Nobel Prize has become the most influential award for scientific and technological achievements. Among them, the Nobel Prize in Chemistry is the highest honor in the field of chemistry. Many of its awarded achievements are cutting-edge inventions and discoveries in chemical science, which to a certain extent represent the development direction of the chemistry discipline. It has not only attracted extensive attention from scientists, but also from a large number of educators. Furthermore, with the deepening of the new curriculum reform, the requirements for teaching have become increasingly stringent. Therefore, teachers need to explore diverse teaching modes to effectively improve the efficiency of classroom teaching. To address the prevailing problems in secondary school chemistry teaching, including the shortage of cutting-edge situational materials, the disconnection between material application and teaching objectives, and the insufficient exploitation of the educational value of Nobel Prize teaching resources, this study systematically collects, classifies, and analyzes the teaching application of teaching materials related to the Nobel Prize in Chemistry, with the goal of implementing the cultivation of core competencies in the chemistry discipline. This research constructs a Nobel Prize teaching resource system adapted to secondary school chemistry teaching, and explores the application paths and implementation strategies of such resources in classroom teaching.

Keywords: Secondary School Chemistry Teaching, Nobel Prize, Situational Teaching.

INTRODUCTION

Senior high school chemistry curriculum attaches great importance to the creation and application of authentic teaching situations, from the design of teaching content and the organization of teaching activities to the evaluation of teaching effects. The General High School Chemistry Curriculum Standard (2017 Edition, Revised in 2020) clearly proposes to take themes as the guide, realize the contextualization of curriculum content, and promote the implementation of disciplinary core competencies. In the proposition guidelines for academic proficiency tests, it is further emphasized that authentic situations should be used as the carrier of test questions to assess students' ability to apply chemistry knowledge to solve practical problems in real situations[2].

At present, secondary school chemistry teachers have widely explored the classroom teaching mode based on authentic situations, but there are still many pain points in practice. First, there is a shortage of high-quality cutting-edge situational materials adapted to the knowledge points of secondary school chemistry, and teachers lack a clear path for the excavation and development of high-quality materials. Second, the classroom application of some materials is disconnected from the core teaching objectives, only limited to the classroom introduction session, failing to run through the whole teaching process, and the educational value of the materials cannot be fully exerted. Third, the difficulty of the materials is not properly controlled, and it is easy for overly professional content to exceed students' cognitive level.

As the highest award in the global natural science field, the Nobel Prize in Chemistry covers cutting-edge discoveries and core breakthroughs in all branches of chemistry. It not only contains core knowledge points that are highly consistent with secondary school chemistry textbooks, but also embodies rich elements of scientific spirit, ideological and political education, and scientific inquiry methods, making it a high-quality resource with great development value in secondary school chemistry teaching. Therefore, this study systematically constructs a Nobel Prize teaching resource system adapted to secondary school chemistry teaching, and explores the effective application paths and strategies of such resources. It has important practical significance for promoting the innovation of situational teaching in secondary school chemistry and implementing the training objectives of disciplinary core competencies[1].

Classification and Functional Evaluation of Nobel Prize Teaching Resources

Combined with the content characteristics of secondary school chemistry teaching and the application scenarios of materials, and referring to existing research results on the classification of chemistry situational materials, this study divides the Nobel Prize teaching resources adapted to secondary school chemistry teaching into four categories. The specific classification and core characteristics are as follows:

Chemistry History and Scientific Story Materials: Centering on the research experience, achievement development process, and scientific exploration stories of Nobel Prize in Chemistry winners, focusing on the transmission of scientific spirit and research methods, and suitable for classroom introduction and ideological and political education sessions.

Life and Social Application Materials: Focusing on the practical application of Nobel Prize achievements in production and daily life, pharmaceutical health, environmental protection, new energy and other fields, which fits students' life cognition, helps students understand the social value of chemistry, and is suitable for knowledge point explanation and exercise design sessions.

Experimental and Inquiry Materials: Taking the core experimental principles, inquiry methods and technological innovations in Nobel Prize achievements as the core, which is highly consistent with secondary school chemistry experimental teaching, and suitable for experimental inquiry and classroom interaction sessions.

Disciplinary Frontier and Knowledge Expansion Materials: Centering on the core knowledge points of secondary school chemistry corresponding to Nobel Prize achievements, connecting textbook content with disciplinary frontiers, helping students build a complete knowledge system, and suitable for classroom summary and extracurricular expansion sessions[3].

To screen high-quality materials adapted to secondary school chemistry teaching, this study analyzes the collected materials one by one, and the results are shown in the table below:

Table 1 Material Analysis

Situational Materials	Classification	Corresponding Chemistry Knowledge Points	Curriculum Ideological and Political Elements
1925 Nobel Prize in Chemistry: Richard Zsigmondy's research on colloid chemistry and ultramicroscopy	Chemistry History and Scientific Story Materials	Classification of dispersion systems, properties and applications of colloids, basic concepts of solutions	Cultivation of rigorous, truth-seeking and innovative scientific inquiry spirit
1911 Nobel Prize in Chemistry: Marie Curie's discovery and research on radioactive elements radium and polonium	Chemistry History and Scientific Story Materials	Concept of elements, basics of atomic structure, periodic law of elements	Scientific dedication, perseverance in research attitude, and role model demonstration education
1904 Nobel Prize in Chemistry: William Ramsay's discovery and research on noble gases	Chemistry History and Scientific Story Materials	Composition of air, periodic table of elements, properties and applications of noble gases	Cultivation of scientific inquiry spirit of being good at discovery and rigorous verification
1909 Nobel Prize in Chemistry: Wilhelm Ostwald's research on catalysis, chemical equilibrium and reaction rate	Chemistry History and Scientific Story Materials	Concept and function of catalysts, influencing factors of chemical reaction rate, basics of chemical equilibrium	Cultivation of scientific spirit of daring to question and seeking truth from facts
1954 Nobel Prize in Chemistry: Linus Pauling's research on chemical bond theory	Chemistry History and Scientific Story Materials	Atomic structure, chemical bonds, periodic law of elements	Cultivation of scientific innovation spirit of daring to break through and explore bravely
2019 Nobel Prize in Chemistry: R&D of lithium-ion batteries (John B. Goodenough, M. Stanley Whittingham, Akira Yoshino)	Life and Social Application Materials	Redox reaction, working principle of primary batteries, properties of metals and their compounds	New energy development and social responsibility, cultivation of scientific innovation spirit
2015 Nobel Prize in Physiology or Medicine: Tu Youyou's research on the extraction and synthesis of artemisinin	Life and Social Application Materials	Separation and purification of substances, extraction operation, structure and properties of organic compounds, basics of chemical experiments	Family and country feelings, cultural confidence in traditional Chinese medicine, scientist spirit and social responsibility cultivation
1995 Nobel Prize in Chemistry: Research on the formation and decomposition mechanism of the ozone layer (Paul Crutzen, Mario Molina, F. Sherwood Rowland)	Life and Social Application Materials	Composition of air, conversion of oxygen and ozone, redox reaction, chemistry and environmental protection	Ecological environment protection awareness, global vision and social responsibility cultivation
1945 Nobel Prize in Chemistry: Artturi Ilmari Virtanen's research on agricultural chemistry and feed preservation	Life and Social Application Materials	Redox reaction, anti-corrosion principle of substances, chemistry and agricultural production	Cultivation of social responsibility for chemistry serving agricultural production and ensuring food security
2023 Nobel Prize in Chemistry: Discovery and synthesis of quantum dots	Life and Social Application Materials	Dispersion systems, nanomaterials, properties of solutions, basics of elemental compounds	Scientific and technological innovation awareness, cognition of the social value of chemistry in the field of people's livelihood
2005 Nobel Prize in Chemistry: Olefin	Experimental and Inquiry Materials	Types of organic chemical reactions, green chemistry concept, synthesis	Green chemistry concept, cultivation of scientific and

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metathesis reaction and green organic synthesis research (Yves Chauvin, Robert H. Grubbs, Richard R. Schrock)		and application of organic compounds	technological innovation and sustainable development awareness
1931 Nobel Prize in Chemistry: High-pressure chemical synthesis method and improvement of synthetic ammonia industry (Carl Bosch, Friedrich Bergius)	Experimental and Inquiry Materials	Properties of nitrogen, reaction principle of synthetic ammonia, chemical reaction rate and equilibrium, chemistry and agricultural production	Great value of chemistry to food security, social significance and social responsibility of industrial chemistry
2010 Nobel Prize in Chemistry: Palladium-catalyzed cross-coupling reactions (Richard F. Heck, Ei-ichi Negishi, Akira Suzuki)	Experimental and Inquiry Materials	Basics of organic synthesis, catalytic effect of metals, redox reaction	Great value of chemistry to pharmaceutical research and development, cultivation of scientific and technological innovation spirit
2000 Nobel Prize in Chemistry: Discovery and research on conductive polymers (Alan J. Heeger, Alan G. MacDiarmid, Hideki Shirakawa)	Experimental and Inquiry Materials	Organic polymer materials, structure and properties of organic compounds, conductors and insulators	Development vision of new materials, innovative scientific spirit of breaking inherent cognition
1973 Nobel Prize in Chemistry: Geoffrey Wilkinson and Ernst Otto Fischer's research on ferrocene and organometallic chemistry	Experimental and Inquiry Materials	Properties of iron compounds, redox reaction, basics of coordination compounds	Scientific inquiry spirit, cultivation of chemical thinking linking microstructure and macroscopic properties
2021 Nobel Prize in Chemistry: Research on asymmetric organocatalysis (Benjamin List, David W.C. MacMillan)	Disciplinary Frontier and Knowledge Expansion Materials	Function of catalysts, principles of organic chemical reactions, basics of chiral molecules	Green chemistry concept, expansion of cutting-edge innovation vision in chemistry
2022 Nobel Prize in Chemistry: Research on click chemistry and bioorthogonal chemistry (Carolyn R. Bertozzi, Morten Meldal, K. Barry Sharpless)	Disciplinary Frontier and Knowledge Expansion Materials	Organic chemical reactions, formation and breakage of chemical bonds, interdisciplinary of chemistry and biology	Interdisciplinary innovation awareness, cognition of the value of chemistry serving life sciences
2018 Nobel Prize in Chemistry: Research on the directed evolution of enzymes (Frances H. Arnold, George P. Smith, Gregory Winter)	Disciplinary Frontier and Knowledge Expansion Materials	Properties of proteins, catalytic function of enzymes, influencing factors of chemical reaction rate	Biomimetic innovative thinking, cultivation of sustainable development concept
2016 Nobel Prize in Chemistry: Design and synthesis of molecular machines (Jean-Pierre Sauvage, Sir J. Fraser Stoddart, Bernard L. Feringa)	Disciplinary Frontier and Knowledge Expansion Materials	Properties of molecules and atoms, chemical bonds, organic molecular structure	Exploration spirit of the microcosm, expansion of scientific and technological innovation vision

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2017 Nobel Prize in Chemistry: Cryo-electron microscopy technology and biomolecular structure determination (Jacques Dubochet, Joachim Frank, Richard Henderson)	Disciplinary Frontier and Knowledge Expansion Materials	Microstructure of substances, chemical experimental observation technology, basics of molecular structure	Cognition that technological innovation promotes scientific development, cultivation of scientific inquiry spirit

Teaching Application Cases of Nobel Prize Teaching Resources in Secondary School Chemistry

High-quality teaching materials can only give full play to their educational value when they are deeply integrated with classroom teaching. This study selects materials that can run through the whole process of classroom teaching and are highly related to the life situations of middle school students, and designs a complete classroom teaching application case as follows:

This case selects the core material of the 2019 Nobel Prize in Chemistry "R&D of Lithium-Ion Batteries". This material covers core knowledge points such as "redox reaction", "working principle of primary batteries" and "metals and their compounds" in the compulsory module of secondary school chemistry, and can realize the whole-process integration of materials and classroom teaching[4].

Classroom Introduction Session: Through physical display of smart phones and new energy vehicle models, combined with the award history of the 2019 Nobel Prize in Chemistry, tell the scientific research stories of the three scientists in the R&D process of lithium-ion batteries, and put forward the core questions "Why can lithium-ion batteries become an invention that changes the world? What is the core chemical principle of its power supply?", so as to stimulate students' inquiry interest and anchor the core knowledge point of "working principle of primary batteries" in this lesson.

Principle Inquiry Session: Combined with the charge-discharge principle of lithium-ion batteries, disassemble the core law of redox reaction, the composition conditions and working principle of primary batteries, guide students to compare the similarities and differences between lithium-ion batteries and copper-zinc primary batteries, establish the connection between old and new knowledge, and help students build a complete knowledge system of primary batteries[5].

Experimental Verification Session: Organize students to carry out group inquiry experiments on the production of copper-zinc primary batteries, guide students to imitate the scientific research and inquiry ideas of Nobel Prize winners, independently explore the core factors affecting the current efficiency of primary batteries, record experimental phenomena, analyze experimental results, and cultivate students' scientific inquiry ability and experimental operation ability.

Expansion and Application Session: Combined with the application of lithium-ion batteries in the field of new energy and energy storage, guide students to analyze the significance of chemical technology to ecological environment protection and sustainable social development, and discuss the environmental problems caused by battery abandonment, cultivate students' sense of social responsibility and green chemistry concept, and realize the organic integration of curriculum ideological and political education and classroom teaching.

Effect Evaluation Session: Taking the electrode reaction of lithium-ion batteries as the core background, design classroom exercises to assess students' mastery of the working principle of primary batteries and redox reaction knowledge points, so as to realize real-time diagnosis and feedback of teaching effects.

Screening Principles of Nobel Prize Teaching Resources

Student-Oriented Principle: Fully understand students' knowledge reserve, cognitive level and psychological characteristics, screen materials in line with the cognitive law of middle school students, control the professional difficulty of materials, and avoid overly esoteric academic content exceeding students' understanding range.

Content Matching Principle: Combined with the chapter content and key and difficult teaching points of senior high school chemistry textbooks, screen Nobel Prize materials that are highly consistent with the core knowledge points, excavate the internal correlation between material content and textbook knowledge, and ensure that materials serve the teaching objectives.

Multiple Value Principle: Give priority to materials with comprehensive coverage of functional characteristics, take into account the multiple educational objectives of knowledge transmission, ability training and ideological and political education, and give full play to the comprehensive educational value of Nobel Prize materials.

Application Strategies of Nobel Prize Teaching Resources

Adaptation Strategy for Material Presentation Forms: Authentic situational materials in chemistry teaching are usually presented in the forms of text, pictures, videos, experimental activities, etc. Materials in different forms have different teaching functions and are also limited by objective teaching conditions. Among them, experimental inquiry activities can carry richer teaching content, effectively concentrate students' attention, and have better teaching effects than other forms, but require sufficient classroom time and complete experimental conditions; text and picture materials are easy to operate and save classroom time, which are suitable for classroom introduction and knowledge point explanation sessions; video materials have strong appeal and can leave a deeper impression on students, which are suitable for extended teaching sessions. In actual teaching, teachers should flexibly choose the presentation form of materials in combination with teaching objectives, classroom duration and teaching conditions.

Combined Application Strategy of Materials: The content of senior high school chemistry classroom teaching is rich with numerous knowledge points, and a single situational material is difficult to support a complete teaching framework and teaching content. Therefore, in actual teaching, at least 2-3 interrelated materials should be selected for combined teaching, while avoiding too single type of materials, so as to realize the organic integration of chemistry history materials, life application materials and experimental inquiry materials. In the combined application of multiple materials, it is necessary to sort out the logical clues between materials, connect materials around the core main line of teaching, avoid classroom logic confusion caused by material stacking, and make situational materials truly serve the teaching objectives.

Whole-Process Integration Strategy of Materials: To avoid the formalization problem that materials are only applied to the classroom introduction session, the Nobel Prize materials should run through the whole teaching process of classroom introduction, principle explanation, experimental inquiry, expansion and application, and effect evaluation. A progressive question chain should be designed around the materials to guide students to complete knowledge learning and construction in the process of solving real problems, and give full play to the educational value of situational materials.

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