Research on Interdisciplinary Teaching Design of "Artificial Intelligence + Digital Chemistry Experiment

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Abstract. Based on the STEAM education concept, artificial intelligence is integrated into the context creation. With "Chemical Detective Agency: Exploring Soda Brothers" as the main thread, a high school chemistry teaching case relying on handheld technology is designed to enhance students' ability to comprehensively apply knowledge to solve practical problems and their higher-order thinking skills, promote the transformation of students' thinking patterns, and achieve advanced thinking. That is, to shift from the basic descriptive and memory-based aspects to higher-level ones such as logical, strategic, progressive, practical and innovative ones. Teachers utilized handheld technology and artificial intelligence, taking sodium carbonate and sodium bicarbonate as carriers, innovated the design of large units, and carried out a series of experimental activities in a progressive manner by class hours.

Keywords: Artificial intelligence; Digital experiment; PH sensor; Interdisciplinary teaching; STEAM education.

1 Introduction

1.1 Research Background

Educational informatization is the fundamental connotation and prominent feature of educational modernization, and it is a key content and significant symbol of "China Education Modernization 2035". The "Education Informatization 2.0 Action Plan" clearly states that it is necessary to adhere to the deep integration of information technology and education and teaching, leverage technological advantages, and achieve fair and quality education. On the one hand, teachers should strengthen the regular application of information technology in their daily teaching. On the other hand, it is also necessary to avoid using for the sake of "using", but to use because of "applicability" [1]. Chemical experiments are an important teaching content for implementing the fundamental task of fostering virtue and nurturing talent in chemistry courses, and their integration with information technology holds significant value.

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1.2 Research Objectives

Build a Teaching Model.

Clarify the integration path and positioning of AI and digital chemistry experiments, form a practical interdisciplinary teaching model, and solve the problem of the disconnection between technology and discipline.

Cultivate Core Competencies.

Simultaneously enhance students' core competencies in chemistry and their AI application capabilities (data modeling and analysis), foster comprehensive problem-solving skills, and promote the development of higher-order thinking.

Verify Practical Value.

Through effect evaluation, verify the effectiveness of the teaching model in enhancing learning interest, knowledge depth, and technical awareness, providing empirical evidence for interdisciplinary teaching reform.

2 Theoretical basis

2.1 Constructivist Learning Theory

Students obtain intuitive data through digital chemical experiments (such as reaction pH and temperature changes), and then use AI to analyze the data (such as fitting curves and predicting results), actively constructing chemical laws and AI application logic, achieving the integration of knowledge from both disciplines.

2.2 STEAM Education Philosophy

Centered on the demands of chemical experiments, it provides technical support through digital experiments (precise data collection), and uses AI to upgrade methods (data processing, simulation prediction), covering dimensions such as science, technology, and mathematics, aiming to cultivate students' cross-disciplinary problem-solving abilities[1]. STEAM organically integrates five subjects (science, technology, engineering, art, and mathematics) for teaching to achieve the goal of interdisciplinary education. Experts and scholars in the field of chemistry have also conducted in-depth research on how to integrate the STEAM education concept with chemistry classrooms.

2.3 Technology Integration Theory

Artificial intelligence does not replace experiments but extends capabilities (such as simulating high-risk experiments); Digital experiments and AI form a closed loop of "data generation - value mining", avoiding the disconnection between technology and teaching[2].

2.4 Theory of Multiple Intelligences

Adapting to the strengths of different students - hands-on students lead experimental operations, logical students are responsible for artificial intelligence analysis, and visual students present results to achieve personalized participation[3].

2.5 Interdisciplinary Teaching Theory

Goal integration to achieve the unification of the goals of "technical tools" and "disciplinary inquiry"[4]. Content integration integrates teaching content with artificial intelligence. Through interdisciplinary task design, ability transfer guides students to apply the "data thinking" of AI to chemical exploration and the "empirical thinking" of chemistry to AI applications, achieving a two-way transfer of cross-disciplinary abilities[5].

3 Research Methods

This study adopts multiple research methods: Firstly, the literature review method, systematically sorting out relevant research achievements at home and abroad, and analyzing the development trends and main models of interdisciplinary teaching in artificial intelligence and digital experiments; The second is the case analysis method, which involves selecting typical teaching cases for in-depth analysis and summarizing effective experiences. The third method is questionnaire survey and interview. Questionnaires are used to collect students' acceptance of interdisciplinary teaching and changes in their learning interests. Through interviews, understand the difficulties and suggestions of students in the application of AI in schools, digital experimental operations, and interdisciplinary learning. Combine quantitative data (questionnaires) and qualitative data (interviews) to comprehensively evaluate the teaching effect.

4 Interdisciplinary Teaching Design Plan of "Artificial Intelligence + Digital Chemistry Experiment"

This study adopts multiple research methods: Firstly, the literature review method, systematically sorting out relevant research achievements at home and abroad, and analyzing the development trends and main models of interdisciplinary teaching in artificial intelligence and digital experiments; The second is the case analysis method, which involves selecting typical teaching cases for in-depth analysis and summarizing effective experiences. The third method is questionnaire survey and interview. Questionnaires are used to collect students' acceptance of interdisciplinary teaching and changes in their learning interests. Through interviews, understand the difficulties and suggestions of students in the application of AI in schools, digital experimental operations, and interdisciplinary learning. Combine quantitative data (questionnaires) and qualitative data (interviews) to comprehensively evaluate the teaching effect.

4.1 Textbook Analysis

Unit Analysis Based on Big Concepts.

This class is based on the diversified, structured and conceptual characteristics of the core literacy of the chemistry discipline. It takes the disciplinary concept of "structure - property - use - value" as the overseer to cover the theme of "Common Inorganic Substances and Their Applications", and deconstructs the secondary and core concepts from the perspectives of macro and micro integration, material categories and element valence states.

The Status and Role of this Section of the Textbook.

Textbook structure: The content of this section is selected from the third class period of the first section of the second chapter of the first volume of the compulsory high school chemistry textbook of the People's Education Edition, titled "Sodium Carbonate and Sodium Bicarbonate", and it is an important part of the knowledge of elements and compounds. Connecting the content of junior high school chemistry, adhering to the basic concept of the chemistry discipline that "structure determines properties and properties determine uses", learning the knowledge of elements and compounds from the perspectives of substance categories and element valence states, building a cognitive model for the subsequent course content learning, and playing a bridging role in the textbook system.

The content of the textbook: The textbook takes sodium and its compounds as the main knowledge line, intersperses sodium carbonate and sodium bicarbonate, pays attention to the transformation between the two, and constructs the research ideas and methods of elements and their compounds from the perspectives of substance category and element valence state. In order to further enhance students' analytical and predictive abilities, improve the exploration of the thermal stability of sodium carbonate and sodium bicarbonate and their reactions with acids, integrate the exercises in the teaching materials, and conduct in-depth research on their properties such as identification, impurity removal and mutual transformation.

4.2 Teaching and Evaluation Objectives

Teaching Objectives.

This class is based on the diversified, structured and conceptual characteristics of the core literacy of the chemistry discipline. It takes the disciplinary concept of "structure - property - use - value" as the overseer to cover the theme of "Common Inorganic Substances and Their Applications", and deconstructs the secondary and core concepts from the perspectives of macro and micro integration, material categories and element valence states.

Macroscopic identification and microscopic analysis: Be capable of distinguishing the thermal stability of sodium carbonate and sodium bicarbonate and the macroscopic phenomena and microscopic principles of their reactions with acids.

Concept of change and balance thought: Be able to write correct ionic and chemical equations based on the category of substances and the valence state of elements, explain

the properties of sodium carbonate and sodium bicarbonate, and correctly distinguish and clarify the transformation relationship between the two.

Evidence reasoning and model cognition: Be capable of understanding the essential characteristics and transformation relationship of sodium carbonate and sodium bicarbonate through methods such as analysis and explanation, establish two-dimensional cognitive models of valence categories, and be able to use models to explain chemical phenomena.

Scientific inquiry and innovation awareness: Be capable of designing experiments on the thermal stability of sodium carbonate and sodium bicarbonate and their reactions with acids by applying the idea of controlling variables and combining qualitative and quantitative approaches.

Scientific Attitude and Social Responsibility: Be able to recognize the significant role of technological innovation in national development from the production history of soda ash.

Evaluation Objectives.

Diagnose and develop students' experimental inquiry levels (qualitative, quantitative, experience-based, and concept-based levels).

Diagnose and develop students' advanced understanding of elements and their compounds (at the levels of matter, element, and particle) and the structured level of their cognitive thinking (at the levels of perspective, connotation, isolation, and system).

Key and Difficult Points of Teaching.

To highlight key points and overcome difficulties, teaching methods such as problem-driven approach, experimental inquiry method and timely evaluation method led by teachers, as well as learning methods such as learning and thinking combination method and inquiry learning method with students as the main body are adopted. Inquiry-based teaching is combined with micro-project-based teaching to fully implement the integration of teaching, learning and assessment, so as to achieve the realization of teaching goals and the cultivation of quality simultaneously.

4.3 Teaching Process

Unit Teaching Approach.

Create a context for a chemistry detective agency, and within the framework of large-unit teaching, achieve advanced cognition, build disciplinary values, and implement core literacy in the chemistry discipline.

Teaching Ideas for Class.

Run through the situational line, problem line, inquiry task line, subject knowledge line, evaluation line, ideological and political education line in the curriculum, quality line, and STEAM penetration line to implement the core literacy of the chemistry discipline.

Evaluation Design.

Design a course evaluation scale, conduct performance-based evaluations through self-assessment, peer assessment, and teacher assessment to achieve a combination of pre-class, in-class, and post-class evaluations, with full participation, promoting the implementation of core literacy, and realizing the integration of teaching, learning, and assessment.

5 Conclusion

This class is based on a thorough study of the teaching materials and connects with daily life, allowing students to carry out an exploration activity by making a soda water project. In the raw material selection stage, students are taught the chemical knowledge points of this lesson in the form of inquiry activities (the reactions of two bases with hydrochloric acid and calcium chloride respectively and their thermal stability). In the experimental stage, the use of sensors is involved. Finally, in the production stage, artistic experience and calculation of production costs are integrated. Let the students experience the charm of five subjects in the process of making a small bottle of soda water.

Author Contributions

Xue Liu conceived the idea of the study and wrote the paper. Hui Wang guided the revision of this paper.

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