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Analysis of Interdisciplinary Cases between Chemistry and Biology Based on the New Curriculum Standards

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Abstract: In high school chemistry teaching, biology is the discipline most closely related to chemistry. Integrating biology with chemistry is an effective way to make high school chemistry classes more efficient. Based on the intersections between the contents of Grade 10 chemistry and biology textbooks, this paper explores the feasibility of connecting biological content with chemistry to build efficient chemistry classes.

Keywords: High school chemistry teaching; Interdisciplinary integration; High school biology

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1. Introduction

Max Planck, the famous German physicist, once said: "Science is an inherent unity. Its division into separate parts is not determined by the nature of things, but by the limitations of human cognitive abilities" [1]. Countries such as Japan and Germany have set up integrated courses, with increasing class hours and extensive teaching content. By teaching around a central issue in one discipline with the help of knowledge from other disciplines, it not only improves students' comprehensive abilities but also facilitates the development of interdisciplinary teaching designs by teachers. Since 2010, interdisciplinary integration has attracted widespread attention in China, and the number of research papers on interdisciplinary integration has surged. The "Interim Measures for Coordinating and Promoting the Construction of World-Class Universities and First-Class Disciplines" points out that while comprehensively deploying and promoting the "Double First-Class" construction, we should "highlight interdisciplinary integration and collaborative innovation" and "encourage the development of emerging and interdisciplinary disciplines" [2]. Some researchers have analyzed the integration of chemistry in biology classes [3]. To sum up, in the teaching process, we need to highlight the characteristics of disciplines while paying attention to the connections between them.

2. The necessity of interdisciplinary integration

The Senior High School Chemistry Curriculum Standards [4] mention that in chemistry teaching, teachers should attach importance to the selection and organization of interdisciplinary content themes, and strengthen the connections between chemistry and physics, biology, geography, materials science, and environmental science. The new curriculum standards emphasize big concepts and unit teaching. An analysis of the content of new textbooks shows that there is a close connection between biology and chemistry courses in Grade 10. For example, "Concept 1: Cells are the basic units of the structure and life activities of organisms" in the Senior High School Biology Curriculum Standards [5] is closely linked to "Theme 4: Simple Organic Compounds and Their Applications" in the Senior High School Chemistry Curriculum Standards. These two parts focus on different aspects and appear successively in the first volume of biology (compulsory) and the second volume of chemistry (compulsory) for Grade 10, with the former laying the groundwork for the latter. The integration of different disciplines deepens the connections between the knowledge students have learned and enhances the comprehensiveness of their knowledge, which is in line with the current requirements and proposition methods of the college entrance examination [6]. It promotes the development of interdisciplinary subjects and thus has far-reaching implications and significance.

3. Current situation of interdisciplinary integration between high school chemistry and biology

3.1. Lack of new ideas and insufficient innovation in teaching practices

Under the background of the new curriculum standards, to further improve the teaching effect of high school biology and chemistry, teachers should conduct in-depth analyses of teaching content and current teaching situations, explore and study students' knowledge of biology and chemistry, and understand their actual needs. Only in this way can the rationality and scientificity of the interdisciplinary content in biology and chemistry courses be ensured, and the teaching content can meet students' expectations [7]. However, many teachers lack the introduction and generation of new ideas when carrying out interdisciplinary integration between high school chemistry and biology under the new curriculum standards, and there is insufficient innovation in teaching practices, which greatly hinders the development of educational work. In the process of integrated teaching of biology and chemistry, teachers adhere to outdated teaching ideas, making it difficult to effectively innovate teaching methods. Some teachers still adopt the cramming method of teaching, which significantly affects students' efficiency in exploring knowledge and is not conducive to improving their learning efficiency [8].

In addition, in the implementation of interdisciplinary education integrating high school chemistry and biology under the new curriculum standards, students' dominant position in the classroom has not been effectively highlighted. Many teachers still place themselves in a dominant position in the classroom, resulting in students' lack of initiative in exploring knowledge in class. They find it difficult to express their views based on the teaching content and are not deeply involved in experimental activities, which hinders the improvement of teaching effects.

3.2. Outdated knowledge and students' inadequate understanding

Under the new curriculum standards, certain changes have occurred in the knowledge of high school biology and chemistry courses. This requires students to participate more actively in knowledge exploration and learning to ensure the effectiveness of education and promote their long-term development. Meanwhile, although the knowledge of high school chemistry and biology courses has been expanded to some extent, it still cannot meet students' expectations for more knowledge in these two subjects. Therefore, when integrating high school biology and chemistry courses, teachers need to introduce more knowledge into the classroom to help students form a more complete knowledge system of biology and chemistry [9]. However, in actual teaching, teachers rarely reasonably introduce high-quality knowledge of biology and chemistry courses, and the expansion of interdisciplinary teaching content is insufficient, which greatly affects the effect of subsequent interdisciplinary teaching between high school chemistry and biology.

In addition, in biology and chemistry teaching under the new curriculum standards, teachers often take textbooks as the main teaching basis. Few teachers can effectively expand textbook knowledge based on teaching content and students' needs, nor can they use Internet technology and new media tools to introduce high-quality digital resources and interesting resources, which also hinders the improvement of students' learning initiative. At the same time, the content of high school biology and chemistry courses is mostly in text form, which leads to difficulties in understanding for some students, is not conducive to improving the effect of interdisciplinary teaching between biology and chemistry, and hinders students' long-term and all-round development [10].

4. Changes in the content of "Basic Nutrients" in the new textbook

In the old PEP textbook, the section "Basic Nutrients" is in Section 4 of Chapter 3 in the second compulsory volume. Its content can be divided into three parts: a brief introduction to carbohydrates, lipids, and proteins from perspectives such as constituent elements; their characteristic reactions; and a brief description of their hydrolysis. In the new textbook, the position of this section remains unchanged, but the content arrangement is more detailed. It is also divided into three parts, but introduces carbohydrates, lipids, and proteins one by one in sequence, rather than mixing them together.

A comparison of specific contents: (1) The section "Carbohydrates" introduces monosaccharides, disaccharides, and polysaccharides in more detail through tables. Compared with the old textbook, it adds information such as representative substances, characteristics, the natural occurrence of representative substances, and their uses. The old textbook included the structures of glucose and fructose, while the new textbook has omitted the structure of fructose. The new textbook adds a detailed experimental process for glucose testing. The old textbook chose sucrose to verify carbohydrate hydrolysis, whereas the new textbook selects to test the hydrolysis products of starch and then introduces carbohydrate hydrolysis. In the corresponding hydrolysis equations of polysaccharides, "cellulose" is added to make the equations complete and more accurate, and finally, the application of hydrolysis is briefly introduced. (2) In the section "Proteins", the new textbook adds an introduction to the dehydration condensation of amino acids, an experiment on protein salting-out, and a comparison between protein salting-out and denaturation. (3) In the section "Fats and Oils", the introduction to saturated fatty acids and unsaturated fatty acids is more detailed. It also adds content about the digestion and absorption of fats and oils, and introduces the differences between animal cream and margarine through the section "Science·Technology·Society".

5. Interdisciplinary integration reflected in the changes of "Basic Nutrients"

By comparing the changes in "Basic Nutrients" in the new chemistry textbook with the contents of "Carbohydrates and Lipids in Cells" and "Proteins as the Main Bearers of Life Activities" in the new compulsory biology textbook (Volume 1) for senior high school, it is found that the expanded content in the new chemistry textbook is consistent with that in the biology textbook. The description of carbohydrates in chemistry textbooks, “People initially found that the chemical composition of most compounds in this category conforms to the general formula $C_n(H_2O)_m$, so carbohydrates are also called saccharides,” is consistent with the biological textbook. The classification of carbohydrates has been changed from “monosaccharides, disaccharides, polysaccharides” (old term) to “monosaccharides, disaccharides, polysaccharides,” unifying the terminology with the biology textbook.

In the old chemistry textbook, the structures of glucose (aldose) and fructose (ketose) were presented, but when introducing glucose detection methods, it did not mention whether the same method could be used for fructose. However, students already learn in biology that both glucose and fructose are reducing sugars, which may confuse them: can fructose, a reducing sugar with a different structure, be detected using the same method? The new chemistry textbook deletes fructose’s structure and retains only glucose’s, which is less likely to confuse students. Nevertheless, teachers still need to integrate and explain relevant content in class to fully resolve such issues. Experiment 7-8 in the chemistry textbook, which asks students to “recall the method for detecting starch learned in biology class,” explicitly highlights the necessity of interdisciplinary integration. Additionally, the new chemistry textbook arranges content in the order of carbohydrates, proteins, and lipids, consistent with the biology textbook, facilitating interdisciplinary integration.

6. Analysis of the teaching of “Basic Nutrients” from the perspective of interdisciplinary integration

Starting from the changes in textbooks, we explore ways to integrate biology into chemistry classes [11]. The content related to carbohydrates, lipids, and proteins appears in both Biology compulsory 1 and Chemistry compulsory 2. Therefore, teachers can use the knowledge learned in biology as a foundation to achieve a seamless connection.

6.1. Connections and differences in “Carbohydrates”

Biology compulsory 1 introduces the concept and classification of carbohydrates, the detection of reducing sugars (such as glucose), the formation of disaccharides and polysaccharides through dehydration condensation of monosaccharides, and the hydrolysis of carbohydrates. On this basis, it focuses on analyzing how different carbohydrates serve as the main energy source for cells. Chemistry, building on the same foundation, emphasizes the principles of carbohydrate hydrolysis, structural differences between different sugars, and the experimental detection of glucose. Based on the above, the study of this part in chemistry can leverage existing biological knowledge, with key integrated explanations as follows:

(1) The detection methods for glucose using freshly prepared copper hydroxide (Fehling’s reagent) and silver ammonia solution under alkaline conditions are also applicable to other reducing sugars.

(2) Monosaccharides undergo dehydration condensation to form disaccharides and polysaccharides, and polysaccharides can be hydrolyzed. The principle of polysaccharide hydrolysis is similar to the esterification reaction in the previous section. The dehydration condensation of monosaccharides and the hydrolysis of polysaccharides can be explained through comparison and analogy.

(3) The chemistry textbook describes the hydrolysis of cellulose as “Herbivores have cellulase in their bodies, which can hydrolyze cellulose into glucose” [12]. The description in the biology textbook is different: “Cellulose is also a polysaccharide, insoluble in water, and difficult to be digested in any

animal's body. Even if herbivores have well-developed digestive organs, they need to rely on certain microorganisms to decompose such polysaccharides." Relevant data [13] shows that the description in the biology textbook is more reasonable. Students can clarify the conditions for cellulose hydrolysis through self-study by consulting materials.

(4) The prevalence of diabetes in China is increasing year by year, and diabetes has become a major disease endangering people's health. The chemistry textbook introduces the detection of diabetes in the form of "information cards," while the biology textbook analyzes the causes of diabetes in connection with society. These two parts can be combined to enable students to systematically understand the formation, detection, hazards and prevention of diabetes.

6.2. Connections and differences in "Proteins"

The introduction of proteins appears in both subjects but with differences:

(1) Review the elements composing proteins and amino acid condensation learned in biology (by analogy with the formation of polysaccharides from monosaccharides and esterification reactions).

(2) Make a smooth transition from the protein structure learned in biology. Since structure determines properties, focus on analyzing protein salting-out and denaturation [14]. Analyze from experimental phenomena that salting-out is reversible while denaturation is irreversible, which can be explained by the protein structure learned in biology: denaturation changes the protein structure, while salting-out does not.

(3) Some applications and detection methods of proteins have already appeared in the biology textbook; on the basis of existing knowledge, new detection methods can be added. The "Thinking and Discussion" section in the textbook mentions the use of formaldehyde to preserve specimens in biological laboratories, allowing students to reconnect with the knowledge learned in biology and find interdisciplinary connections and knowledge coherence.

6.3. Connections and differences in "Lipids"

The knowledge related to lipids has the following connections:

(1) Regarding the description of lipids, the biology textbook classifies fats into plant fats and animal fats, while the chemistry textbook refers to plant lipids as "oils" and animal lipids as "fats." This classification method is more reasonable, and the relevant descriptions in biology can be further improved during teaching.

(2) The structure of lipids appears in both biology and chemistry textbooks but with different writing methods. The writing method in the chemistry textbook highlights functional groups, but the two can be unified and analyzed comparatively.

(3) The biology textbook introduces the functions of fats, while the chemistry textbook focuses on analyzing the functional groups in their structure and then introduces the manufacturing principle of margarine.

The integration of chemistry and biology promotes students to shift from learning isolated knowledge points to constructing systematic scientific thinking. While understanding the chemical nature of life phenomena, students deepen their cognition of chemical reaction principles, experimental exploration methods, and scientific ethics, comprehensively improving their core literacy in chemistry [15], and laying a solid foundation for future scientific exploration and solving real-world problems.

7. Conclusion

Amid the ongoing advancement of China's new curriculum standards, core competencies have become a pivotal objective in basic education reform. Chemistry and biology, as closely interconnected disciplines within natural sciences, exemplify this trend. This paper examines the new textbooks' innovations in content organization, knowledge integration, and experimental design centered on "basic nutrients," highlighting their role in demonstrating interdisciplinary convergence between chemistry and biology. By implementing core competencies such as the "structure-function perspective" and "matter-energy perspective" from biology, students gain a deeper understanding of organic compounds' properties, reaction mechanisms, and practical applications. Meanwhile, chemical microscopism and theorem-based reasoning offer fresh interpretations of biological phenomena. The dual complementary teaching model effectively bridges disciplinary gaps, enhances classroom efficiency, and cultivates systematic scientific cognition while developing students' inquiry skills and social responsibility awareness.

Disclosure statement

The author declares no conflict of interest.

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