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An Exploration of Discipline-Centered Interdisciplinary Practical Teaching in Junior High School Chemistry Under the New Curriculum Standards

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Abstract: Breaking down the barriers of single-subject chemistry teaching is now important for improving the education of introductory chemistry. As a basic subject that connects the comprehension of macroscopic matter with microscopic particle thought, junior high school chemistry is suitable for combination with other subjects such as physics, mathematics, and ethics and law. Based on the chemistry discipline, this paper specifically studies the advantages of tiered teaching in interdisciplinary junior high school chemistry education from five aspects: knowledge construction, cognitive development, ability training, moral education and teacher improvement. It investigates how the STSE educational concept enlarges the range of interdisciplinary practical activities in chemistry, thus offering a pedagogical guide for front-line chemistry teachers to carry out interdisciplinary teaching properly and promote core chemical abilities.

Keywords: Junior high school chemistry; Interdisciplinary teaching; Discipline-centered

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1. The connotation and value of interdisciplinary practical activities

The Compulsory Education Curriculum Framework (2022 Edition) requires that every subject should allocate no less than 10% of the class hours for interdisciplinary thematic learning to promote integration and cooperation among different subjects [1]. It is an indispensable approach to implement the 2022 Compulsory Education Chemistry Curriculum Standards and solve the present problems of chemistry as a single course in junior high schools. It has significant practical importance in five aspects: knowledge, thinking ability, skills, personal development and teaching research. Firstly, at the stage of knowledge construction, it can overcome the knowledge barriers among various scientific disciplines. By using prerequisite and related knowledge

from physics, biology, geography and so on, it can resolve the teaching difficulties like microscopic concepts and experimental principles in chemistry, make up for students' deficiencies in fragmented knowledge, and help them establish a complete and systematic cognitive structure of the subject; Secondly, at the level of thinking improvement, it makes use of the thinking methods from other subjects to specifically train the three major types of chemical thinking - triple representation, evidence-based reasoning and quantitative conservation, thus overcoming the learning obstacles brought by junior high students' poor abstract thinking ability in chemistry and paying attention to the gradual improvement of specific scientific thinking in the subject; Thirdly, in terms of ability training, teaching situations are designed based on real life and comprehensive problems, which conforms to the trend of context-related questions in the senior high school entrance examination, and can effectively enhance the students' chemistry laboratory skills, information evaluation abilities and practical innovative capabilities to solve actual chemical problems; Finally, morally, the plan borrows the subject-specific materials, such as chemical pollution, chemical production and laboratory safety, to integrate moral education contents, including ecological civilization, scientific spirit and safety standards.

1.1. Knowledge construction dimension

By utilizing knowledge from different fields, the curriculum improves the organized knowledge system of chemistry to connect the students' previous science background and overcome the difficulties resulting from incomplete chemical concepts. To solve the problem of inadequate prior knowledge of the students, basic principles from physics and biology are applied to facilitate the understanding of chemistry.

1.2. Cognitive development dimension

By adopting interdisciplinary thinking approaches, we develop scientific thinking particular to chemistry in a step-by-step way. We apply the well-known thinking techniques from other fields specifically to solve the three main cognitive problems in chemistry, namely microscopic thinking, evidence-based reasoning and quantitative calculations, so that the students can absorb chemistry-specific scientific thinking instead of general science thinking. To deal with the difficulty of microscopic abstraction, a "triple representation" system is set up for chemical thinking.

1.3. Competency development dimensions

By utilizing genuine and combined scenarios, we aim to gradually improve the students' ability in solving chemical problems. With real-life, combined scenarios as a means, we shall teach the students to distinguish the irrelevant information from the chemical problems and use the chemical principles to deal with practical issues—regarding the scenario as the "shell" and chemistry as the "core". At the same time, we will reinforce the basic laboratory skills of the students. By integrating basic physical principles such as sedimentation, filtration, and pressure, we will standardize the detailed procedures of some basic chemical experiments, for example, water purification and the purification of coarse salt. We will also rectify the common errors in the students' experimental practices to increase the standardization of the basic chemical experiments and their operational abilities. The evaluation standards for the laboratory work still conform to the specifications of the national curriculum for chemistry.

1.4. Moral education dimension

Leveraging the intrinsic materials of chemistry, we will carry out tiered and subject-specific moral education. By utilizing the moral education resources existing in the subject itself and avoiding the strict external imposition of political ideology, we will combine the moral education objectives with the main concepts of chemistry, such as chemical reactions, chemical production and chemical pollution, so as to cultivate virtue intrinsically in the chemistry class. Promote a serious and standardized awareness of chemical safety. By studying the inherent properties of chemical substances, such as flammable and explosive chemicals, strong acids and bases and medical disinfectants, we can spread the common sense of laboratory safety and the proper use of household chemical products. The safety education is based on the characteristics of chemical substances and is consistent with the intrinsic teaching content of chemistry courses. Enable the students to know the causes of environmental pollution and the principles of its remediation through the basic nature of chemical reactions, thus establishing the disciplinary environmental concepts like green chemistry and zero-pollution reaction design.

1.5. Teacher development dimension

Regarding the problems in chemistry teaching, this program intends to improve the chemistry teachers' professional skills by means of progressive professional development. It helps teachers apply the new curriculum requirements, solves deficiencies in class instruction, and enhances their capability in designing large units and carrying out contextual teaching - not to prepare them as generalists with interdisciplinary knowledge, but rather specialists.

2. Expansion and deepening of interdisciplinary practical activities

In the 2022 version of the new chemistry curriculum standards, the "Chemistry and Society · Integrated Practice" theme shows the close relationship between interdisciplinary practical activities and STEM [2]. This combination not only enlarges the teaching methods and usage range of interdisciplinary practical activities but also enhances their importance in the chemistry field. By means of this method, students can not only improve their knowledge of specific subjects but also enhance their ability to solve problems and be creative, thereby forming comprehensive core abilities which are beneficial for dealing with future social issues [3].

3. STEM: An interdisciplinary educational model

STEM education is a teaching method that combines project-based learning and the knowledge and techniques from science, technology, engineering, and mathematics. Different from the conventional subject-oriented educational systems, STEM education does not merely combine the knowledge from different subjects; instead, it integrates the knowledge and techniques of these subjects into a whole problem-solving procedure by taking real-life problems as the beginning of the learning process. This way of teaching is inherently interdisciplinary, contextual, practical, cooperative and based on evidence, indicating a new trend in interdisciplinary learning [4].

4. Current shortcomings in interdisciplinary (STEM) chemistry instruction in junior high school

According to the feedback from the front-line classrooms, the present chemistry teaching in junior high schools, although discipline-based and trying to integrate interdisciplinary and STEM education, still has some practical difficulties that are objective problems that can not be avoided at present.

4.1. At the instructional level: Significant time constraints make routine integration difficult to implement

Because of the large amount of teaching materials and the heavy pressure of exam preparation for the high school entrance examination, the regular classes mainly concentrate on explaining the important concepts and giving practice problems. Even when arranging simplified STEM micro-projects, they are likely to occupy the time that is needed for introducing new knowledge and reviewing exercises; most schools can only carry out cross-disciplinary activities such as open classes or demonstration lectures, which makes it hard to include them in every regular chemistry class. Thus, cross-disciplinary teaching encounters a special "performance-oriented" problem.

5. Prospects for interdisciplinary teaching in junior high school chemistry

Considering the above-mentioned drawbacks, according to the new curriculum standards reform, the changes in high school entrance examination questions, and the development of smart education, this part describes the future of chemistry education concentrating on the subject itself.

5.1. Outlook on teaching models: Promoting embedded micro-integration to realize routine and smooth teaching

In the future, we will not carry out large-scale STEM projects during specific class periods, but instead actively promote embedded micro-interdisciplinary teaching in daily class time. The interdisciplinary ideas and STEM elements will be integrated gradually into all stages of instruction, such as new lesson presentation, experimental investigation and exercise revision, with each integration taking place within 3 to 5 minutes and without the need for separate class periods. Thus, the interdisciplinary instruction can be smoothly combined with the regular chemistry classes and effectively solve the problem of insufficient class time.

6. Conclusion

In conclusion, the main point of interdisciplinary and STEM education in junior high school chemistry is to apply interdisciplinarity as an approach and to take chemistry as the basis. By recognizing present teaching difficulties, firmly maintaining the basic principles of the subject, and conducting integrated teaching in a concise, regular and specific way, interdisciplinary teaching can effectively promote the improvement of fundamental chemistry abilities and make contributions to the high-standard development of primary chemistry courses in junior high school. Teachers should improve their interdisciplinary concepts through experience, increase their designing and executing skills, and achieve instructional optimization through continuous investigation.

Interdisciplinary practical teaching guided by a single core discipline has become an effective innovative path to break the fragmentation of subject knowledge in junior high school chemistry classrooms [5]. Different from traditional scattered interdisciplinary activities, this teaching mode centers on chemistry curriculum standards, integrates biological experiments, environmental geography cases and mathematical data analysis into chemical teaching scenarios, which solves the common defect that early interdisciplinary teaching lacks disciplinary core orientation [6]. The core innovation of this model lies in two aspects: first, it sets clear chemistry knowledge objectives as the main line to avoid the confusion of teaching focus caused by excessive cross-disciplinary expansion; second, it designs operable practical tasks for junior high students, combining daily life chemical phenomena with multi-subject thinking training, rather than staying at theoretical discussion only. Classroom practice data show that this innovative interdisciplinary teaching method can significantly improve students' comprehensive scientific inquiry ability and subject application awareness. In summary, discipline-centered interdisciplinary practical teaching provides a targeted, operable and standard-compliant innovative teaching scheme for junior high chemistry under the new curriculum background, which can be widely promoted in basic science education.

Disclosure statement

The author declares no conflict of interest.

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