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Teaching Design of High School Chemistry with the Integrated Concept of Teaching, Learning, and Evaluation: A Case Study of Iron and Its Compounds

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Abstract The disconnection between teaching, learning, and evaluation is particularly pronounced in traditional high school chemistry teaching. To align with the demands of the new curriculum standards for talent development, it is essential to implement reforms and innovations in teaching methods. This paper initially elucidates the integrated concept of teaching, learning, and evaluation, as well as its practical significance in the classroom. Subsequently, it explores the effective teaching design centered on the theme of iron and its compounds, actively investigating the implementation approach of the integration principle of teaching, learning, and evaluation in classroom. Furthermore, the paper emphasizes the pivotal role of the evaluation part in fostering the professional development of teachers and enhancing the core competencies of students, ultimately aiming to achieve high efficiency and quality in chemistry classroom teaching.

Key words Integration of teaching, learning, and evaluation, High school chemistry, Teaching design, Iron and its compounds, Classroom teaching, Core competency

0 Introduction

The *Chemistry Curriculum Standards for General High Schools* (2017 *Edition*, *Revised in* 2020) (hereinafter referred to as the *New Curriculum Standards*) explicitly articulates the concept of integrated curriculum education encompassing teaching, learning, and evaluation. The primary objective of this concept is to achieve a seamless integration of teachers' teaching practices, students' learning experiences, and evaluation methods[1]. This concept addresses the issues arising from the separation of teaching and evaluation, as well as the absence of evaluation links that are prevalent in contemporary high school chemistry classrooms, aiming to promote the holistic development of students through the integration of teaching and evaluation.

1 Connotation of the integration of teaching, learning, and evaluation

Teaching, learning, and evaluation collectively aim to achieve a distinct objective, creating an interconnected framework in which these three elements are closely associated with the central goal, thereby influencing and enhancing one another. The teaching practices of teachers and the learning experiences of students, along with the evaluation of both teaching and learning, are intricately connected and mutually integrated under the framework of established teaching goals. Evaluation serves several functions, including guidance, regulation, and supervision within the teaching process. The activities associated with evaluation and those related to teaching are collaboratively engaged in the pursuit of teaching objectives[2]. The *New Curriculum Standards* stipulate that, in accordance with the academic quality standards for chemistry, the evaluation of students' core competencies in the subject should be conducted at various stages of learning. Furthermore, it is essential to promote the integration of teaching, learning, and evaluation to facilitate the progressive development of each student's core competencies in chemistry[3].

2 Importance of the integrated teaching model of teaching, learning, and evaluation in chemistry teaching

The implementation of an integrated teaching model that encompasses teaching, learning, and evaluation in high school chemistry teaching is a highly innovative and practical teaching method. This model effectively combines the dual functions of teaching and evaluation, thereby enhancing the teaching-learning process and fostering increased interaction between teachers and students. This teaching model places a greater emphasis on the enhancement of students' abilities, aligning with the objectives of the recent curriculum reform[4]. In contrast to traditional teaching and evaluation model, the integrated model of teaching, learning, and evaluation offers distinct teaching advantages. The emphasis has shifted from solely concentrating on students' learning outcomes to placing greater importance on students' learning behaviors and the attainment of learning objectives. Within the integrated teaching model of teaching, learning, and evaluation, students are positioned as the central figures in the classroom, while the teaching objectives receive heightened attention from teachers. This transition has led to an increase in student engagement in their learning processes and has fostered their intrinsic motivation. Simultaneously, teachers must formulate lesson plans that align with the new teaching model, establish teaching objectives for each time frame (quarterly, monthly, semi-monthly, and weekly), and systematically incorporate evaluation into the chemistry classroom. Furthermore, students have the opportunity to assess the teaching methods and application methods employed by their teachers, which serves

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to enhance teachers' motivation for innovation and create an engaging atmosphere in the classroom. By systematically collecting and analyzing the teaching and learning data produced throughout the teaching process, teachers can perpetually refine and improve both the content and delivery of their lessons. This information offers teachers real-time feedback on their teaching practices, which not only assists them in identifying challenges but also empowers them to make timely adjustments to their teaching methods, thereby enhancing the overall quality of classroom teaching.

3 Teaching design of the second lesson of iron and its compounds under the integrated concept of teaching, learning, and evaluation

3.1 Preparation for pre-course design and evaluation The teaching design for the topic of iron and its compounds is developed in accordance with the integrated characteristics of teaching, learning, and evaluation. This approach emphasizes the alignment of teaching and evaluation objectives, as well as the synchronization of learning activities with evaluation tasks. A foundational comprehension of employing elemental valence to analyze and identify redox reactions is acquired in chapter one. In the contemporary educational environment, there exists significant potential for enhancement in students' analytical, critical thinking, and inquiry skills. While students have acquired a foundational understanding of the redox properties of substances, it is essential that this knowledge should be further developed and solidified through practical applications[5]. Such experiences are crucial for the effective integration of this knowledge into students' long-term cognitive frameworks. The development of teaching scenarios and experimental investigations within this course will facilitate students in acquiring a more thorough and nuanced understanding of the properties of substances. From the standpoint of social development, students can recognize the relationship between chemistry and human society, thereby fostering a sense of social responsibility. Engaging in various inquiry-based activities centered around chemistry themes allows students to experience the scientific research process, ultimately cultivating a sense of scientific inquiry that can transform their learning methods.

3.1.1 Teaching objectives. Three teaching objectives have been established: (i) to enhance understanding of the properties of iron and ferrous salts through the lens of material classification and valency, to comprehend the transformation relationships associated with valence-variable elements, and to broaden the conceptual frameworks and methods for studying chemical substances; (ii) to investigate the redox reactions of trivalent and divalent iron through experimental research, thereby recognizing the significant role that empirical studies play in elucidating the nature of substances and fostering a sense of evidence-based reasoning; (iii) to instill an appreciation for the substantial contributions of chemistry to the advancement of human society and to acknowledge the intrinsic value of chemistry as a discipline, illustrated through practical applications.

3.1.2 Evaluation objectives. Three evaluation objectives have been delineated: (i) to enhance students' exploratory skills and deepen their comprehension of chemistry by examining the effects of iron supplements on the human body; (ii) to advance students' proficiency in innovative experimental design through the exchange and critique of experimental protocols aimed at identifying divalent and trivalent iron; (iii) to fortify students' cognitive engagement with the transformation of substances by discussing and critiquing the relationship between the transformations of divalent and trivalent iron.

The specific teaching design and evaluation concepts are illustrated in Fig. 1.

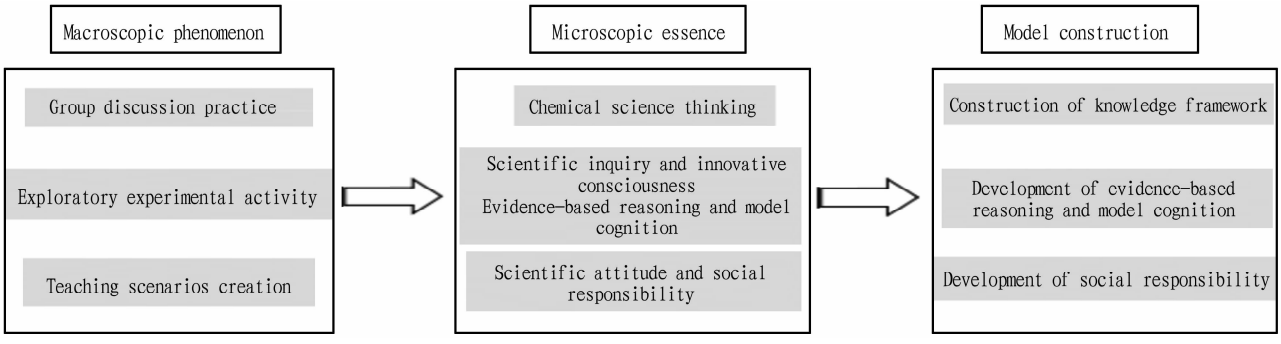

Fig. 1 Teaching design and evaluation concepts

3.2 Design of the teaching process In the classroom, teachers should prioritize both learning and evaluation tasks in their teaching. When addressing the topic of iron and its compounds, teachers are encouraged to initiate the lesson by utilizing multimedia resources in Learning Task One to enhance students' comprehension of the various forms of iron found in iron supplements. Additionally, the incorporation of real-life examples is essential to engage students' interest effectively. Throughout this teaching process, teachers should assess the development of students' scientific thinking by analyzing their interpretations of the different forms of iron present in these supplements. Teachers should facilitate group discussions in Learning Task Two to promote active student engagement and the construction of knowledge frameworks. During these discussions, teachers should anticipate and guide students in progressively uncovering the chemical properties of divalent iron (Fe^{2+}) and trivalent iron (Fe^{3+}). Subsequently, the teacher should design an experimental protocol based on the available reagents to verify the redox properties of divalent iron ions and trivalent iron ions. Through this experimental investigation of the chemical properties of divalent iron ions and trivalent iron ions, teachers

can assess students' predictive capabilities and their proficiency in scientific inquiry. In Learning Task Three, teachers request that the students comprehend and summarize the interrelationship among iron ions, ferrous ions, and trivalent iron ions, utilizing the knowledge they have acquired. This exercise aims to assess the students' capacity to synthesize and articulate the content they have learned. In Learning Task Four, teachers formulate a plan for an experiment aimed at identifying iron ions, utilizing the reagents provided. They organize group experiments to facilitate collaborative learning, enhance the effectiveness of intuitive teaching methods, and encourage students to articulate their ideas and engage in innovative thinking throughout the experimental process. In the course of the experiment, students will identify problems, refine the experimental process, and address these issues, thereby fostering their experimental skills and enhancing their capacity for independent problem-solving. Upon completion of the experiment, students are expected to improve the success rate of their outcomes, reinforce their retention of knowledge, and consequently elevate their overall competencies and innovative capabilities. In Learning Task Five, teachers assess students' proficiency in developing transformation models grounded in redox reactions, specifically focusing on the conversion relationship between divalent iron ions and trivalent iron ions.

3.3 Design of teaching evaluation methods In teaching evaluation, the implementation of a comprehensive and systematic evaluation approach is crucial for enhancing students' learning outcomes and for the continuous improvement of teachers' teaching methods. The teaching process of this course is delineated into three distinct stages of evaluation: pre-class, in-class, and post-class. Each stage is characterized by specific evaluation methods and objectives (Table 1).

Table 1 Evaluation of student classroom performance

	Evaluation criteria//points				Evaluation method		
	Excellent	Good	Average	Poor	Self	Mutual	Teacher
	10 – 9	8 – 6	5 – 3	2 – 0	evaluation	evaluation	evaluation
1. Prepare the lesson before class and complete the preparatory homework							
2. Characterize the properties of divalent and trivalent iron through experimental investigations							
3. Analyze the identification method of divalent and trivalent iron, and master a range of concepts and methods for their identification							
4. Enhance the understanding of the diversity within the field of chemistry by examining the conversion processes of divalent and trivalent iron, and formulate coherent explanations and predictions regarding the properties and transformations of various substances							
5. Maintain a positive mindset and respond with enthusiasm							
6. Clear delineation of responsibilities and comprehensive discussion during collaborative tasks							
7. Careful completion of knowledge compilation and homework assignments							
Total score							

3.3.1 Pre-class evaluation. In the pre-class phase, teachers assign preparatory homework to students to facilitate their comprehension of the content that will be covered in subsequent lessons. Teachers provide informational cards detailing the role of iron in the human body. By engaging with these informational cards, students are able to read and comprehend the content, which allows teachers to gain initial insights into students' perceptions and comprehension regarding the new knowledge. Through students' comprehension and interpretation of this information, teachers can evaluate students' capacity for autonomous learning, their ability to screen information, and their problem-solving skills. Additionally, teachers can gain insights into students' interest in new knowledge and their attitudes toward learning by analyzing feedback on their homework.

3.3.2 In-class evaluation. In-class evaluation constitutes a fundamental component of teaching evaluation, primarily carried out through classroom exercises and the evaluation of students' performance within the classroom. In the classroom, teachers develop practice questions that align with the teaching content to evaluate students' comprehension and mastery of the knowledge based on their responses. Furthermore, students' performance during class serves as a significant criterion for in-class evaluation. Teachers' observations and documentation can provide insights into various dimensions of student engagement, including participation, collaborative skills, and cognitive abilities.

3.3.3 Post-class evaluation. Post-class evaluation serves as an extension and enhancement of the teaching evaluation process, primarily implemented through post-class exercises and chapter tests. Teachers assign pertinent exercises to students after class to facilitate the consolidation and application of the knowledge acquired. Through the completion of homework and the accuracy of students' responses, teachers can gain deeper insights into students' mastery of content and their ability to apply knowledge. Furthermore, upon the conclusion of each chapter, teachers will administer assessments to evaluate students' learning outcomes and their comprehension of the knowledge.

In conclusion, the process of teaching evaluation is both comprehensive and systematic, comprising three distinct stages: pre-class, in-class, and post-class. Each stage employs unique evaluation methods and serves specific purposes, which not only complement one another but also interconnect to form a cohesive teaching evaluation system. This evaluation method enables teachers to gain a deeper understanding of students' learning status and needs, thereby allowing for the adjustment of teaching methods and strategies to enhance the quality and effectiveness of teaching.

4 Conclusions and reflections

Within the integrated framework of teaching, learning, and evaluation, the educational process emphasizes the importance of a strong alignment between teaching objectives and evaluation objectives, as well as the close integration of learning tasks and evaluation activities. This alignment allows teachers to meticulously design teaching content, methods, and evaluation methods from a holistic perspective, thereby significantly improving the effectiveness of classroom teaching[6]. In this model, students are situated within a problem-solving environment that involves real tasks. Through practical engagement and exploration, they inherently enhance their knowledge and develop effective learning methods. This learning process not only fosters the interconnection of knowledge but also enhances the development of cognitive structures. This teaching method underscores the coherence and systematic nature of education, facilitating the interdependence of teaching, learning, and evaluation, thereby allowing these elements to mutually support and advance one another. Compounds of iron are prevalent and utilized in both industrial production and everyday life. Firstly, by highlighting the essential role of iron in the human body, students' interest in learning is effectively stimulated, encouraging them to engage in active and proactive study. Secondly, through group experiments, students engage with the chemical properties of iron ions in a hands-on manner. This experiential learning fosters genuine interest and stimulates critical thinking, significantly enhancing their motivation to investigate the underlying mechanisms of oxidation-reduction reactions involving iron ions. Thirdly, from the perspectives of substance classification and the valence states of elements, students can gain a comprehensive understanding of iron and its compounds, thereby acquiring knowledge pertinent to the element of iron. Through the implementation of group experiments, multimedia presentations, and various instructional aids, abstract and complex concepts are contextualized within real-life scenarios. This approach not only diminishes the learning challenges faced by students but also fosters a more conducive and relaxed learning environment.

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Due to the differences of different types of students, colleges and universities should pay attention to the classification of students with and without entrepreneurship experience, excavate entrepreneurship problems, solve entrepreneurship problems, build self-efficacy for students who have tried entrepreneurship, and then transfer knowledge related to entrepreneurship, so as to realize the integration of theory and practice.

4.2.3 Finding out the key problems and turning "negative influence" into positive promotion. In order to improve the entrepreneurial intention of college students, it is necessary to pay attention to the negative impact of college students' past entrepreneurial experience and find out the crux of the potential impact on students' entrepreneurial intention. Targeted improvement and promotion will transform the negative impact into a positive impact.

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