Research on Interdisciplinary Progressive Questioning Teaching Focused on Core Disciplinary Literacy: A Case Study of the Law of Conservation of Mass in “The Song of the Red Cliff”

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Abstract. This study examines the cultivation of students’ core competencies across various disciplines and investigates the knowledge background in relation to classroom learning environments. Utilizing the layered questioning teaching method, the study aims to foster an interdisciplinary, innovative learning environment for students. The primary focus is junior high school chemistry instruction, specifically the teaching of the "Law of Conservation of Mass." By employing "The Song of the Red Cliff" as the learning context, the study integrates knowledge from the realms of Chinese literature, physics, and chemistry, facilitating an inclusive classroom teaching strategy. This approach not only enriches students' interdisciplinary thinking but also enhances their learning capabilities. The findings offer invaluable insights for middle school educators seeking to improve student learning outcomes.

1. Introduction
Interdisciplinary teaching is an educational methodology that transcends the confines of a singular discipline. No one close to interdisciplinary work fails to notice that it has many faces[1]. It amalgamates knowledge and methods from various disciplines, aiming to foster holistic learning around a specific theme or problem. This approach is designed to tackle complex problems students often encounter, problems that necessitate the application of learnings and skill sets derived from multiple disciplines. Growing attention is being devoted to interdisciplinary learning in science education[4].

The six pivotal attributes of interdisciplinary learning are authenticity, practicality, diversity, inquiry, interdisciplinarity, and integration. These attributes not only stress the amalgamation of knowledge within disciplines but also underscore the linkage between knowledge and methods across various subjects, thereby augmenting the collaborative and instructive functions of the curriculum. The author believes that transforming, multidisciplinary work on the part of both students and faculty is a necessity for effective interdisciplinary higher education[2].

In contrast to conventional subject-specific teaching, interdisciplinary teaching aligns more closely with the intricate nature of education. It endeavors to unearth the inherent associations between different subjects, thereby leading to enhanced classroom teaching outcomes. Moreover, it cultivates students' comprehensive problem-solving abilities that extend beyond the application of knowledge from a singular discipline, involving the cohesive use of knowledge and methods from diverse disciplines.

It is crucial to understand that interdisciplinary learning does not aim to supersede subject-specific learning; instead, it seeks to build upon it. Only when the knowledge and skills from each discipline are thoroughly grasped can interdisciplinary learning be effectively enacted.

2. Content Analysis
Lesson 1 of Unit 5, "Chemical Equations," in the 9th-grade chemistry textbook published by People's Education Press, covers the law of conservation of mass. This fundamental element of middle school chemistry education holds substantial significance throughout a student's chemistry learning trajectory. The law of conservation of mass is intimately linked not only with subsequent studies of chemical equations but also resonates with the concept of "conservation of mass" found in selected ancient Chinese poems and literature. Additionally, the enduring principles of physics embody this disciplinary concept.

Departing from traditional classroom methodologies, this lesson adopts "The Law of Conservation of Mass in the 'The Song of the Red Cliff'" as its central theme. The teaching approach revolves around progressive questioning. Through continuous, multi-level questioning, the lesson deeply dissects the pertinent knowledge of the law of conservation of mass in middle school chemistry from the perspectives of Chinese language, chemistry, and physics. While the need to redefine the core of general chemis-try is current, the topic has been at the...
focus of the education community over the past few decades[3].

The objective is to elevate students' comprehension of the subject matter and enable its application in multiple dimensions. Through this process, students transition from a uni-disciplinary mindset to a multi-disciplinary one, fostering a holistic understanding and cognition of the "structure-property-application" triad. This process cultivates students' core disciplinary literacy, which is an ultimate aim of education. The initiative equipped students with the skills to recognize underlying chemical principles in other disciplines and to solve interdisciplinary problems without “sacrificing” the original chemistry content in the course[5].

3. Teaching Objectives

The functional relationship between teaching objectives and students' cognition in Figure 1.

Upon analyzing teaching materials and curriculum standards, the following pedagogical objectives have been formulated:

Fig. 1. The functional relationship between teaching objectives and students' cognition

1. The primary goal is to guide students in exploring the underlying chemical principles in "The Song of the Red Cliff" through the interpretation of its poetic imagery. This immersive learning experience in the classroom will revolve around the core concept of "conservation of mass."

2. The second objective is to elucidate the three fundamental laws of physics, thereby helping students comprehend the role and significance of the disciplinary concept of "conservation of matter" in physics. This understanding will aid in recognizing its applicability in addressing dynamic problems.

3. A third aim is to underscore the importance and practical application of the law of conservation of mass in chemistry. By emphasizing the concept that total mass remains constant before and after a chemical reaction, we aim to reinforce students' cognitive grasp of this concept.

4. Finally, we aim to analyze the "law of conservation of mass" from a multidisciplinary perspective. This approach will foster diversified learning thinking in students and further cultivate their core disciplinary literacy throughout the teaching process.

4. Teaching Process

4.1. Establishing a Chinese Language Environment and Project Theme

Teaching Session 1

[Project Introduction] Please appreciate the penultimate paragraph of "The Song of the Red Cliff".

[Teacher’s Question] Please consider the modern discipline thinking, which discipline thoughts are included in this part?

[Expected Student Behavior] This poem contains the idea of conservation, the idea of the broad sense versus the narrow sense.

[Teacher-Led Transition] The students have answered correctly. Today, let's focus on understanding the discipline idea of "conservation of mass" and then open our new lesson - "conservation of mass law".

[Teaching Design Intent] The question is asked at the beginning of the class to create a Chinese subject situation and integrate senior high school Chinese knowledge and chemistry knowledge across disciplines. Through the form of appreciation and analysis of poetry, subject projects are introduced and questions are asked at the beginning of the class to attract students to deeply participate in the situation, stimulate students' thinking, improve students' concentration on the class, and then improve the overall class effect.

4.2. Regressing to a Chemical Perspective: A Deep Analysis of the Classroom

Teaching Session 2

[Teacher’s Question] Please think about how the discipline idea of "conservation of mass" is applied to chemistry? Or, in chemistry, this idea of the discipline is presented in what way?

[Expected Student Behavior] May be related to the total mass of the substance before and after the reaction.

[Teacher-Led Transition] Great! Next, the students are invited to divide into groups and design their own experiments according to all the experimental instruments and reagents in class to re-prove the law of conservation of mass.

[Expected Student Behavior] Based on the existing experimental instruments and reagents, the following experimental schemes can be designed: The gas
collecting cylinder and rubber plug with holes are used as the reaction container, and a certain mass of white phosphorus is weighed and put into the reaction container, and then a certain mass of hot water about 90 degrees Celsius is weighed into the syringe, and the reaction container is connected through the rubber plug with holes to form a reaction generating device, and then the whole experimental device is placed on the electronic balance. After checking the air tightness of the experimental device, the water in the syringe is injected into the gas collecting cylinder, and several experiments are started. Finally, the experimental data are observed as a whole and a conclusion is drawn.

[Summary of experimental phenomenon] When the water in the syringe is pushed into the gas cylinder, it can be obviously observed that the white phosphorus is burned and a large amount of white smoke is generated. At the same time, it can be seen that the piston of the syringe slowly moves upward with the beginning of the reaction, and the indicator number of the electronic balance gradually decreases. However, in the process of cooling the experimental device to room temperature, it was observed that the piston of the syringe gradually moved downward, and the final indicator of the electronic balance was the same as before the reaction. After many tests, the experimental phenomenon is the same, that is, in a closed container, the total mass of the substance before and after the reaction does not change.

[Teacher-Led Transition] The above theoretical practice is carried out from the macro level, then, does the law of conservation of mass apply to the micro level? How are we going to explain this? Let's ask the students to think.

[Expected Student Behavior] From the perspective of the chemical equation, the type and number of the same atoms on both sides of the reaction order will not change, and the type of atoms that make up the substance before and after the reaction will not change, and the number of atoms will not change.

[Summary] In this link, we interpret knowledge from macro and micro perspectives. First, at the macro level, we know the important concept that "in a closed container, the total mass of matter before and after reaction will not change"; At the microscopic level, we also draw the important conclusion from the chemical equation that "the type of atoms that make up the substance before and after the reaction does not change, and the number of atoms does not change".

[Teacher-Led Transition] "The law of conservation of mass" the theory of chemical reaction itself, whether at the macro level or the micro level is undoubtedly a very significant discovery, then, in physics, the law of conservation of mass has what kind of application, let's explore together.

[Teaching Design Intent] The question is asked at the key point of teaching. By introducing the historical facts of chemistry, the perspective of chemistry discipline is returned, the subject theme of the class - chemistry is named, and the subjective initiative and innovative consciousness of students are cultivated through experimental inquiry, and the scientific spirit of exploring the essence by phenomena is cultivated, aiming at cultivating the core quality of the discipline of "students' awareness of scientific inquiry and innovation". Then, through the transformation from macro to micro perspective, students are led to learn deeper knowledge and transform their cognitive concepts. The whole process aims to cultivate students' core quality of "macro identification and micro analysis".

4.3. Shifting the Paradigm of Physical Thinking: Multidimensional Knowledge Expansion

Teaching Session 3

[Teacher’s Question] Students have learned the most basic theory of dynamics - "the movement of matter", which students based on the knowledge of physics to explain this law?

[Expected Student Behavior] In physical change, no matter how the shape, state and position of the object change, the mass contained in it remains unchanged; When an object is divided into several parts, the sum of the masses of the parts is equal to the mass of the original object.

[Teacher-Led Transition] It is quite correct to say that the law of conservation of mass from a physical perspective exists in all aspects of our lives, just as water condenses into ice, its density will decrease and its volume will increase, but only its mass will not change. It can be seen that the "law of conservation of mass" has been closely related to our lives before we have systematically learned it.

[Teaching Design Intent] Questions are asked at the knowledge progression, guiding students to explore from subject knowledge to real life, promoting students' thinking, stimulating students' cognitive thinking, combining with real situations, allowing students to feel the close connection between knowledge and life, reflecting the concept of change. Then stimulate students' interest in learning and improve students' positive enthusiasm for learning.

4.4. Differentiating Knowledge and Evaluating Reflection

Teaching Session 4

[Teacher’s Question] What insights have you gleaned from this lesson?

[Expected Student Behavior] When faced with any question or knowledge we have acquired, we should not approach it from a single viewpoint. We need to be adaptable and cultivate the ability to think in varied ways. This approach will yield more benefits and uncover many minute details that we typically overlook.

[Lesson Summary] In this lesson, we delved into the law of conservation of mass, analyzing the knowledge in depth from the perspectives of three subjects: Chinese, Chemistry, and Physics. This demonstrated that a specific knowledge is not exclusive to a particular subject, and there are no high barriers between subjects. As the saying goes, "the world is never deficient in beauty, it only lacks eyes keen on discovering it." Our task is to shatter the
rigid thinking of single-mindedness, learn to be flexible and adaptable, making our learning journey more profound. Next, we invite students from each group to share their learning insights, techniques, and the value derived from this interdisciplinary teaching lesson.

[Communication and Evaluation] Students engage in discussions about their perspectives and thoughts on this lesson, thereby refining their multidimensional disciplinary thinking.

[Teaching Design Intent] The questions are posed at the summary and evaluation stage, serving the pivotal role of prompting inquiry, guiding students towards self-reflection and thought. We aim to instill in students that learning is not confined, but open and diverse. This approach disrupts conventional thinking, fosters students’ interest in learning, plants the seeds of lifelong learning, and gradually guides students to form inductive logic, cultivates self-learning abilities, and leads students to understand the general approach to scientific exploration. This fosters a rigorous scientific spirit and ultimately aims to nurture students’ core competency of "concept of change and balanced thinking".

5. Conclusion

Interdisciplinary teaching is an innovative pedagogical approach introduced in the 21st century, characterized by its timeliness and creativity. However, an examination of numerous classroom instances reveals that this methodology imposes stringent expectations on students, teachers, and even schools. If teachers students and schools can successfully navigate the challenges of interdisciplinary education, the resultant classroom outcomes could reach unprecedented heights. Such success would invigorate future pedagogical practices, infusing them with even more vitality.

References