

Exploration on Interdisciplinary Teaching Practice of Biology in High School -- Taking "Brewing of Fruit Wine" as an Example

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Abstract: In today's society, complex problems show an explosive growth trend, and the solution of these problems often requires the use of multidisciplinary knowledge and relies on interdisciplinary thinking, which is difficult to deal with by a single subject knowledge. The interdisciplinary teaching mode provides students with a learning environment for the integration of multiple knowledge, so that students can widely contact and learn the unique thinking mode of different disciplines, and deeply master the knowledge system in different fields, so as to broaden their thinking horizons, break the discipline barriers flexibly call multidisciplinary knowledge in the face of complex problems, analyze and solve them from multiple angles, truly realize the integration and flexible use of knowledge, and lay a solid foundation for students' future integration into society and coping with complex and changing practical challenges. This paper takes "brewing of fruit wine" as an example to create a real learning situation, stimulate students' interest in learning in the form of questions, and cultivate students' scientific thinking; Cultivate students' teamwork and practical operation ability in group cooperation; Guide students to solve problems with comprehensive knowledge in practical activities, so as to promote the development of students' core literacy in biology.

Keywords: Interdisciplinary Teaching; High School Biology; Brewing of Fruit Wine; Anaerobic Respiration

1. Introduction

At present, China's social development has entered a new stage, and the traditional single subject teaching mode is difficult to meet the needs of the development of students' integrated thinking and complex problem-solving ability

[1]. There is an urgent need to cultivate students' ability to comprehensively use multidisciplinary knowledge to solve practical problems. The United States and Germany took the lead in integrating interdisciplinary concepts into the science curriculum standards and successfully implemented them in educational practice. Their research and exploration in interdisciplinary concept teaching has been quite mature, and has had a far-reaching and positive impact on the global education reform [2]. China's high school biology curriculum standard (2020 Edition) clearly points out that in the teaching process, we should attach great importance to the internal connection and integration between disciplines, guide students to flexibly use the knowledge and method system of multi-disciplinary, and by promoting interdisciplinary integration, we can cultivate diversified talents to meet future needs [3].

2. Overview of Interdisciplinary Teaching

According to the biology curriculum standard for senior high schools (2022 Edition), in teaching practice, teachers should attach great importance to the internal relationship between disciplines. It is an innovative teaching mode, which aims to break the boundaries of traditional disciplines and carry out teaching activities through the in-depth integration of knowledge and thinking methods of different disciplines. Interdisciplinary practical activities include interdisciplinary and practical components, which link the knowledge of different disciplines with practice, reflecting its basic characteristics of comprehensiveness and practicality [4]. Its core is to take a certain subject as the center and realize the integration of multidisciplinary knowledge. It should be emphasized that interdisciplinary teaching is by no means a simple accumulation of knowledge. Disciplines do not exist in isolation, but pursue the organic integration, correlation and penetration between disciplines, and ultimately build a closely

connected knowledge system.

The biology curriculum standard for compulsory education (2022 Edition) points out that biology teaching should focus on cultivating students' core qualities such as life concept, scientific thinking, inquiry practice and attitude responsibility [5]. In the specific teaching process, through interdisciplinary learning, students can develop diversified ways of thinking, use multidisciplinary knowledge and methods, solve complex problems in real life, realize the comprehensive development of core literacy, and lay a solid foundation for students' future development. Based on this, teachers must deeply understand the essence of interdisciplinary learning. In the process of teaching, teachers need to: Z Pay attention to the links between disciplines, set up interdisciplinary theme learning activities, strengthen the links between disciplines, drive the comprehensive implementation of the curriculum, and strengthen the practical requirements. H actively guide students to carry out interdisciplinary learning, and help students understand the close relationship between discipline and society.

3. Advantages of Interdisciplinary Teaching

3.1 Compliance with National Education Reform needs

Carrying out interdisciplinary teaching is a requirement of the national education reform. The biology curriculum standard for compulsory education (2022 version) (hereinafter referred to as the "new curriculum standard") adds the learning theme of "interdisciplinary practice" to the curriculum content structure, and clearly requires that interdisciplinary practice activities strengthen the interrelationship between disciplines, improve the comprehensiveness and practicality of the curriculum, and promote the development of students' core literacy [6].

With the help of interdisciplinary practice activities, we can strengthen the internal relationship between disciplines, improve the comprehensiveness and practicality of the course, and then comprehensively promote the advanced development of students' core literacy. The new curriculum standard focuses on students' active participation in the learning process, advocates the design of learning tasks based on real situations, and guides students to use knowledge and solve problems in situations close to the reality of life, so as to realize the internalization

and transfer of knowledge. The addition of the learning theme of "biology and society · interdisciplinary practice" is to build a bridge for students to connect biological knowledge with social reality and the integration of multidisciplinary knowledge, so that students can cultivate the ability to comprehensively use knowledge in the interaction and collision of multidisciplinary knowledge.

3.2 Remedy the Defects of Discipline Based Teaching Mode

Make up for the deficiency of subject based teaching at present, the school education mode still takes subject based teaching as the main structure. In this mode, each subject carries out teaching activities according to its own independent knowledge system, emphasizing the systematicness and integrity of subject knowledge. However, society is a complex organic whole, and the problems students face in their daily life are often not limited to a single subject field, but show the characteristics of interdisciplinary integration. Although subject based teaching has certain advantages in the depth teaching of subject knowledge, it limits the comprehensive development of students' thinking to a certain extent. This kind of teaching mode is easy to make students form a single subject thinking pattern, which is not conducive to cultivating students' diversified thinking, and makes it difficult for students to flexibly apply their knowledge to real life, and can not effectively deal with complex problems in the real world.

In sharp contrast, interdisciplinary teaching organically integrates the knowledge content of multiple disciplines, breaking the boundaries between traditional disciplines. In the process of interdisciplinary teaching, students can be exposed to thinking modes and research methods from different disciplines, which helps to broaden students' thinking horizons and cultivate students' ability to analyze and solve problems from multiple perspectives. Through interdisciplinary learning, students can establish a more comprehensive and systematic knowledge system, improve the comprehensive application ability of knowledge, and better adapt to the needs of social development.

4. Suggestions on Implementing Interdisciplinary Teaching

4.1 Deepen Interdisciplinary Connection between Disciplines

Teachers should deeply explore the relationship between disciplines and improve teaching efficiency under the background of deepening education reform interdisciplinary teaching has become the key path to improve teaching quality and cultivate students' comprehensive quality. In interdisciplinary teaching, teachers need to have cultural consciousness, so as to better adhere to the main position of Building Morality and cultivating people, guide students to integrate different cultural perspectives, and cultivate students' cross-cultural awareness [7].

In the actual teaching process, teachers need to take a holistic view of various disciplines, study teaching materials, sort out the context of knowledge, and clearly know which knowledge points in the biology discipline can be connected with other disciplines, so as to maintain the subjectivity of the biology curriculum and skillfully realize the cross integration with other disciplines. Teachers' strengthening their teaching quality is also a link that can not be ignored. On the one hand, teachers should constantly update their knowledge of biology and keep up with the frontier of subject development; On the other hand, it is also necessary to widely understand the cutting-edge dynamics of other disciplines. Only in this way can teachers flexibly use multidisciplinary knowledge in the classroom and present abstract knowledge to students in a richer and diversified way.

4.2 Adhere to Biology-Centered Teaching Orientation.

Teachers should play a leading and guiding role, not "cross" for the sake of "cross". They should rely on biology teaching, guide students to learn the knowledge of the subject in a unique way of

biology, and create real and comprehensive situations based on the knowledge, skills and methods of biology, and social hot spots such as daily life, engineering practice and social development as task driving [8].

This is because the real situation can stimulate students' interest in learning and desire to explore, so that students can deeply feel the close connection between knowledge and real life. In the process of solving problems, students' thinking will constantly jump and integrate between the knowledge systems of different disciplines. In order to cooperate with the change of students' learning style, teachers need to carefully design attractive problem situations or theme projects. This requires teachers to fully understand students' interests and knowledge reserves, and guide students to actively explore knowledge based on problems.

As interdisciplinary teaching covers many disciplines, students need to collect, sort out and analyze information by themselves. In this process, teachers should reasonably set up learning groups according to students' interests, specialties and subject advantages. Reasonable grouping can promote the complementary advantages between students and improve learning efficiency. In group cooperative learning, teachers should provide guidance and support for students' cooperative learning.

5. Interdisciplinary Teaching Strategies

In the innovative practice of interdisciplinary teaching, taking the project of "brewing fruit wine" as a typical example (Table 1), the system is divided into three closely connected stages: before class, during class and after class. Each stage complements each other and helps students realize the deep understanding and flexible application of knowledge, fully highlighting the unique advantages of interdisciplinary teaching.

Table 1. Interdisciplinary Instructional Design Cases

Basic links	Teacher activities	Student activities
Before class	1. Prepare students, textbooks and teaching methods 2. Identify learning topics 3. Setting teaching objectives	Pre class preview and data access
In class	Inquiry learning based on the teaching strategy of question string	1. Research on group Cooperation 2. Achievement display and sharing
after class	Assign homework after class and internalize learning knowledge	Find out and fill the gaps, and establish a complete knowledge structure system.

5.1 Grasp students Cognitive Level before Class

Understanding students' cognitive level before

class is the cornerstone of effective teaching design. When designing interdisciplinary teaching, we should fully understand the existing ability level of students, ensure that the selected

interdisciplinary knowledge content can be accepted by students, and improve and exercise their high-level thinking through students' Internalization of basic knowledge [9].

Through the analysis of students' classroom performance and in-depth communication with students, teachers can accurately grasp the knowledge reserve, learning ability and habit differences of students at different levels. Based on the detailed analysis of learning situation, teachers can teach students in accordance with their aptitude, choose the most appropriate teaching strategies, ensure that the teaching content and methods meet the learning needs of all kinds of students, and let every student grow in the classroom.

In depth analysis of the curriculum standards and a comprehensive grasp of the curriculum objectives, content requirements and academic quality standards are the fundamental principles of teaching. The teacher combed the content of the textbook as a whole, focused on the theme of fruit wine brewing, and deeply studied the principle of fruit wine brewing in biology, including the core knowledge of yeast fermentation process and condition control. At the same time, we should carry out interdisciplinary lesson preparation, such as understanding the changes of substances in the fermentation process with the help of chemical knowledge, and accurately calculating the proportion of raw materials and fermentation time with mathematical knowledge, so that students can understand knowledge from a multidisciplinary perspective and broaden their knowledge horizons.

5.1.1 Confirm Integrated teaching Theme

Determine the learning theme the principle and application of cell respiration in Section 3 of Chapter 5 in biology compulsory 1 molecules and cells published by people's education press, and the fermentation engineering in Chapter 1 of biology selective compulsory 3 biotechnology and Engineering published by people's education press, are closely related and can be integrated into one learning chapter for teaching. The teacher determines the learning theme through the three preparations before class: brewing fruit wine - the brewing process carries profound economic value and cultural heritage, but students know little about the principle of brewing. Through the learning of this section, students can understand how to turn accidental discoveries into inheritable processes, master

theoretical knowledge and improve labor skills. After determining the teaching theme, create a real problem situation, and guide students to carry out fermentation experiments, brewing fruit wine and other inquiry activities. In this process, students will learn the knowledge of biology, chemistry, history and other disciplines, cultivate comprehensive thinking, improve the ability to solve problems, and realize the mastery of knowledge.

5.1.2 Formulation of Teaching Objectives

Carry out interdisciplinary lesson preparation related to chemistry, history, geography and literature, and develop the teaching objectives of "brewing fruit wine":

- (1) Understand yeast from the molecular level, form the viewpoint that the structure and function are compatible, and can explain the related fermentation phenomena. Understand the conditions affecting microbial fermentation (temperature, oxygen, pH)
- (2) Understand the chemical reaction of sugar alcohol carbon dioxide in the process of fruit wine fermentation, and summarize the chemical reaction formula of anaerobic respiration.
- (3) Understand the historical story of the introduction of fruit wine into China, feel the cultural inheritance of fermentation technology, and identify with the wisdom of the ancient working people, so as to enhance the national cultural pride.
- (4) The effects of temperature difference between day and night, climate conditions on the sugar content of grapes, and the relationship between different geographical environments and the flavor of fruit wine were analyzed.
- (5) Complete the experimental design and operation in the form of group cooperation, and cultivate the ability of team cooperation, practice and innovation. Use multidisciplinary knowledge to solve problems in fermentation and cultivate students' ability to solve problems.

5.2 Classroom Implementation of Interdisciplinary Teaching

The teaching in class takes the production of fruit wine as the learning theme, creates rich learning situations, uses the problem chain teaching strategy to drive students' learning motivation, realizes the organic integration of biology and geography, history, chemistry and other disciplines, expands students' thinking, and significantly improves students' ability to use comprehensive knowledge to solve problems.

5.2.1 Create problem scenarios to stimulate interest in learning

fruit wine was introduced to the Central Plains when Zhang Qian was sent to the western regions to open up the Silk Road during the Western Han Dynasty. The cultural documentary "Silk Road and fruit wine" was broadcast to show the relevant historical material fragments of historical records biographies of Dawan, which led to the core question of this section - how did grapes introduced from the western regions become mellow wine in the Central Plains? What chemical changes have taken place? The interdisciplinary inquiry task was released. The students were divided into four groups to consult the data from biology (fermentation principle), chemistry (material change), history (Cultural Heritage) and Geography (raw material planting) and complete the pre class preview.

Create problem scenarios to introduce theme learning from Zhang Qian's Silk Road. Through the introduction of culture and history, students can feel the charm of Chinese traditional culture and stimulate students' interest in bioengineering. As well as learning the impact of climate on plants in geography, laying a theoretical foundation for the selection of grapes for brewing, reflecting the correlation of interdisciplinary knowledge.

5.2.2 Question-driven and Cooperative Inquiry

Teachers play videos of brewing fruit wine with traditional fermentation technology, and guide students to think about the following questions:

- (1) What is traditional fermentation technology?
- (2) What is the principle of using traditional fermentation technology to produce fruit wine?

After watching the video, students come to the conclusion that traditional fermentation technology refers to a technological means of directly using the naturally existing microorganisms in raw materials to carry out fermentation to produce food. The principle used in the production of grape wine is to make use of the respiratory principle of yeast, a single-cell fungus. After students understand the traditional fermentation technology in the video, they can further throw out the progressive question chain:

- (1) From the perspective of biology and chemistry, why is grape a high-quality material for wine making?
- (2) Why can traditional brewing succeed without deliberately adding yeast, but modern brewing usually adds yeast? Why?
- (3) Why should the temperature be controlled at 18-30° and a third of the space be reserved in the bottle during traditional fermentation? What scientific basis does this contain?

Table II Four groups were used to carry out the practical operation, and each group focused on key variables to carry out the comparative experiment (Table 2). During the practical operation, the students considered and discussed the following issues:

- (1) What are the factors that affect the taste of fruit wine? How to choose grapes?
- (2) Why can't the grapes be washed too clean?
- (3) Why should the fermentation temperature be controlled at 18-30 °C?
- (4) Why flush first and then remove the stem?
- (5) Why do you need to loosen the bottle cap once rather than open the bottle cap once at an interval in the brewing process?

Table 2 Experimental Design of Fruit Wine Brewing with Different Grape Raw Materials

group	Experimental variable	Control conditions	Exploration objectives
first group	Grape variety (red/white, with skin), wide mouth bottle, gauze, sugar, alcohol (70%)	The temperature is 18-20 °C, yeast is added, and the sugar content is the same	This group explored the relationship between grape varieties and wine color and flavor
Group 2	Red grapes (stemmed and peeled), flasks, gauze, sugar, alcohol (70%)	The temperature is 18-20 °C, yeast is added, and the sugar content is the same	Study on the influence of peel on fruit wine color
Group 3	White grape (stemmed), jar, yeast, gauze, sugar, alcohol (70%)	Temperature: 18-20 °C, red grape with skin and consistent sugar content	Explore the effect of yeast on fermentation efficiency
Group 4	Red grape (stemmed), flask, yeast, gauze, sugar, alcohol (70%)	Red grape with skin, yeast and the same sugar content	Explore the Effect of temperature on fermentation speed

Create progressive problem scenarios, drive students' interest in learning in the form of problem strings, promote students' active thinking, cultivate the ability to observe and

analyze problems, and improve the level of team cooperation through group communication and discussion.

5.2.3 Idea collision for in-depth comprehension

Besides yeast, are there other microorganisms during fruit wine fermentation? Will they affect the fermentation of fruit wine? If yes, how to avoid this effect? After thinking and discussing, students also answered lactic acid bacteria, acetic acid bacteria, molds and other microorganisms. Lactic acid bacteria may use the sugar in fruit juice for lactic acid fermentation to produce lactic acid. An appropriate amount of lactic acid can increase the flavor complexity of fruit wine, but if lactic acid fermentation is excessive, the acidity of fruit wine will increase, the taste will become sour and astringent, and the quality of fruit wine will be affected. Acetic acid bacteria can convert ethanol into acetic acid, leading to the rancidity of fruit wine and reducing the quality and taste of fruit wine. Mold can inhibit the fermentation of yeast, make the fermentation of fruit wine incomplete and produce peculiar smell. To further guide students to explore how to avoid this effect, we can explore the influence of temperature, oxygen and pH on fruit wine fermentation by controlling fermentation conditions.

5.2.4 Knowledge consolidation and ability improvement

During the fermentation process, the team adding a large number of yeast found that the fermentation was completed in only five days, and a large number of bubbles appeared. The bubbles were identified as carbon dioxide through hydrated lime water. Next, the students summarize the fermentation reaction of yeast according to their biological and chemical knowledge: first, they determine that the reactant is sugar, and yeast plays the role of enzyme and catalysis in the fermentation process, and finally generates ethanol and CO₂. Some organic acids will be obtained by prolonging fermentation time. Therefore, the reaction equation of yeast fermentation can be obtained as follows:

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH$ (alcohol) + $2CO_2$ + a small amount of energy

$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$ (lactic acid) + a small amount of energy

Through the study of this course, the practical assignment "brewing apple vinegar" is arranged to promote the application of knowledge in real life, internalize and construct the knowledge learned through hands-on operation, cultivate students' hands-on operation ability, improve students' labor consciousness, and further consolidate the learning achievements of interdisciplinary knowledge.

5.2.5 Diversified evaluation and classroom feedback

Traditional teaching process pays too much attention to the evaluation of students' academic performance, which is more one-sided for the evaluation of students, and is not conducive to the comprehensive development of students.

In interdisciplinary teaching activities, we should pay attention to the process evaluation and overall evaluation of students, and pay attention to the evaluation of students' mastery of knowledge, their ability to cooperate and explore in groups, and their learning attitude. The evaluation methods can include teacher evaluation, student mutual evaluation and student self-evaluation. Taking "brewing fruit wine" as an example, we always pay attention to the evaluation of students' thinking ability and team cooperation ability in the whole teaching process, give full play to the positive role of evaluation, and stimulate the subjective initiative of learning.

Carry out the class fruit wine display. The students show their own wine. The excellent fruit wine in the group is selected by the group and displayed to the whole class. They also explain their exploration process to other groups. After the display, other groups raise questions for interactive communication. Through the interaction between groups, each group can find out the omissions and fill the gaps from the experience of other groups, develop their own thinking, and further improve their understanding of the brewing process. Student evaluation is a process in which teachers and students participate together. Teachers should pay attention to the guidance of students to ensure the smooth interaction between students.

5.3 Summary and Reflection of Teaching Activities

Through the interdisciplinary teaching of "brewing fruit wine", students not only master the fermentation principle of yeast in biology, but also understand the cultural and historical allusions of fruit wine and traditional fermentation technology. The key to sublimating the teaching effect through interdisciplinary practical activities is to integrate multidisciplinary knowledge into the teaching process, so as to deepen students' understanding of biological concepts and stimulate their learning interest and innovation ability [10].

However, due to the long implementation time

of the activity of "brewing fruit wine" and the lack of rigor in students' operating skills, teachers should give students appropriate guidance in the teaching process, pay attention to the safety of the whole activity process, and do not taste the fruit wine brewed by themselves at will, so as not to endanger health.

6. Concluding Remarks

The practice of interdisciplinary teaching activities with the theme of "brewing of fruit wine" has deepened students' understanding of biological knowledge, learned to realize the transfer and application of knowledge, and cultivated students' innovative thinking and problem-solving ability through the integration of multidisciplinary knowledge and skills. Through the organic integration of multidisciplinary knowledge, this teaching mode can not only deepen students' understanding of biological concepts, but also help them build a systematic knowledge system, so as to comprehensively improve their core literacy based on deep learning.

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