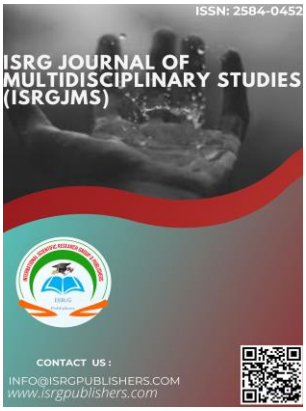
ISRG Journal of Multidisciplinary Studies (ISRGJMS)

ISRG PUBLISHERS
Abbreviated Key Title: isrg j. multidiscip. Stud.
ISSN: 2584-0452 (Online)
Journal homepage: https://isrgpublishers.com/isrgjms/
Volume – II Issue – XI (November) 2024
Frequency: Monthly



Exploration of Innovative Experimental Teaching Design in High School Biology Based on the ADDIE Model--Taking "Comparing the Decomposition of Hydrogen Peroxide under Different Conditions" as an Example

Shaoqun Ma[1*], Jiayi Kong[2], Xiaojie Gao[3]

[1] College of Life Sciences, Qinghai Normal University, Xining, Qinghai, 810000, China
[2] Academy of Plateau Science and Sustainability, Xining 810016, P. R. China
[3] Key Laboratory of Biodiversity Formation Mechanism and Comprehensive Utilization of the Qinghai-Tibet Plateau in Qinghai Province, Qinghai Normal university, Xining, 810008, China

| **Received:** 30.10.2024 | **Accepted:** 03.11.2024 | **Published:** 14.11.2024

***Corresponding author:** Shaoqun Ma
College of Life Sciences, Qinghai Normal University, Xining, Qinghai, 810000, China

Abstract

This paper takes "comparing the decomposition of hydrogen peroxide under different conditions" as an example, and designs a set of high school biology experimental teaching design based on the ADDIE model, aiming at improving students' experimental skills, experimental innovation and problem solving ability, improving the quality of experimental teaching and cultivating students' core literacy in biology.

Keywords: *ADDIE model; core literacy in biology; laboratory instruction*

1. Introduction

The General High School Biology Curriculum Standards (2017 Edition Revised in 2020) (hereinafter referred to as the "new standards") pointed out that in the teaching process, it is necessary to "pay great attention to the practical experience of the students' learning process, emphasize that the process of students' learning is the process of active participation, and allow students to actively participate in hands-on and minds-on activities" [1]. Hands and brain activities, through exploratory learning activities or to complete engineering learning tasks, to deepen the understanding of biological concepts, enhance the ability to apply knowledge, and cultivate the spirit of innovation" [1]. Based on this, teachers can use the ADDIE model to implement the teaching concepts of the new

DOI: 10.5281/zenodo.14160419

standards in the process of experimental teaching. ADDIE is a teaching model developed and designed by the Center for Educational Technology at Florida State University, which mainly covers five phases of analysis, design, development, implementation and evaluation [2], and ensures that each phase is fully considered by carrying out the design of experimental teaching in accordance with the sequence of the five phases and improve the effect of experimental teaching. Through the preliminary investigation in this paper, we hope to provide reference value for first-line biology teachers.

2. Advantages of high school biology laboratory teaching based on the ADDIE model

2.1. Helps teachers to systematize and analyze the various elements of instructional design for biology experiments

In the analysis stage, teachers conduct a comprehensive analysis of the course objectives, teaching content, teaching methods, teaching environment, school resources, etc., use the ADDIE model to assess the students' learning level, learning styles, interests and learning needs, identify and solve teaching problems, and formulate an experimental teaching program that meets the actual situation of students. At the same time, we analyze the advantages and shortcomings of the experiments in the textbooks, clarify the objectives and priorities of experimental teaching, and guide students to be innovative in experiments without being confined to the experimental programs in the textbooks.

2.2. Helps teachers develop effective and innovative instructional programs

The ADDIE model is a flexible design framework. During the development stage, teachers make adjustments to the experimental design according to specific teaching scenarios and student characteristics, and select suitable teaching strategies and methods according to different needs, so as to develop activities, assessment tools and evaluation criteria suitable for this experimental lesson, and create more suitable, effective and innovative teaching programs to ensure that the experimental lesson can be carried out with high quality.

2.3. Contribute to the ability to comprehensively and objectively assess the effectiveness of biology laboratory instruction

Teaching evaluation is both a result and a starting point. In the evaluation stage, teachers evaluate the experimental teaching process systematically, objectively and comprehensively according to the preset objectives and evaluation criteria, including the degree of realization of the course objectives, the degree of students' participation, the effectiveness of the teaching methods, the students' learning effects, the degree of utilization of the teaching resources, and the quality of the teacher's teaching, etc., so that problems can be found in a timely manner and adjustments and improvements can be made to improve the effectiveness and quality of teaching.

3. Experimental teaching process based on the ADDIE model

3.1. Analysis phase

3.1.1. Analysis of the Standards

The new curriculum requires that the teaching process should emphasize practice, and at the same time aims at developing students' core literacy in biology. Authentic and effective experimental teaching is the practical point of biology teaching and points to the development of students' core literacy in biology, such as scientific thinking and scientific inquiry, and the promotion of students' use of the views, knowledge, ideas and methods of the discipline of biology to explore or solve certain problems in real life.

3.1.2. Experimental analyses

Based on the textbook experiments and pre-laboratory analysis, it was found that the textbook experimental program has the following shortcomings: the use of high temperature heating process there are safety hazards, the use of water bath heating is difficult to achieve constant temperature heating; the bubbles generated in the experiment are not easy to observe in the case of insufficient light or background interference; the use of hygienic incense is not easy to combust, the experimental phenomenon is not intuitive and obvious; the use of the liver is not easy to grind and preservation, the freshness of which directly affects the experimental The freshness of the used liver is not easy to grind and preserve, which directly affects the effect of the experiment, and it is not easy to clean the test tubes; the failure to quantitatively detect the rate of oxygen production under different conditions affects the accuracy of the experimental results.

3.1.3. Teacher analysis

In the process of teaching analysis, effective self-analysis can improve the quality of teaching and student learning, but most teachers only analyze their students and teaching, and their own analysis is more lacking. Teachers should conduct self-analysis from the perspectives of design and organization, guidance and supervision, evaluation and feedback, encouragement and facilitation, and resource integration to continuously improve their professionalism and teaching skills. And teachers should become lifelong learners and continuously self-optimize to better promote the development of education.

3.2. Design stage

3.2.1. Design of Teaching Objectives

Based on the requirements of cultivating students' core literacy, the teaching objectives are designed as follows: to understand the biocatalytic mechanism of enzymes by comparing the hydrolysis of hydrogen peroxide under different conditions and applying the concept of structure-function compatibility; to be able to design experimental solutions creatively based on experimental problems by applying the concept of innovation; to master the basic methods of scientific investigation by cultivating the students' ability of observing experiments and analyzing data, explaining experimental phenomena, and investigating the results; to understand the practical applications of enzyme engineering in real life, and to have some plans for future career development. Students will be able to understand the practical application of enzyme engineering in real life, and have certain plans for their future career development.

3.2.2. Design of teaching content

This experimental lesson is set up in two lessons. In the first lesson, students first read the relevant teaching materials independently, conduct experiments under the guidance of the teacher, find

DOI: 10.5281/zenodo.14160419

problems in the experimental process, for the problems found, the group independently consult relevant information, find solutions and innovative experimental program. In the second lesson, the group presents the newly designed experimental scheme, implements the scheme when conditions permit, observes the experimental results and checks the expectations before the experiment, interprets and analyzes the experimental results and experimental phenomena, and shares the experimental experience together after the experiment.

3.2.3. Developing Student Competencies and Core Literacy Design in Biology

Teachers need to design how to develop students' competence during the experiment and at the same time develop students' core literacy in the discipline of biology. The development of competence in this lesson can be designed as shown in Figure 1. For example, in the stage of data collection and data analysis, students exercise the ability to collect experimental data accurately, record the completeness and accuracy of the data, and process and analyze the experimental data using appropriate methods of statistics, analysis, and generalization and summarization, so as to cultivate scientific thinking; in the stage of problem solving and experimental innovation, when it is found that liver is not easy to be grinded and preserved, and that its freshness directly influences the results of the experiments, the teacher can guide students to find new experimental materials from life to replace liver, to enhance students' problem solving and innovative thinking ability.

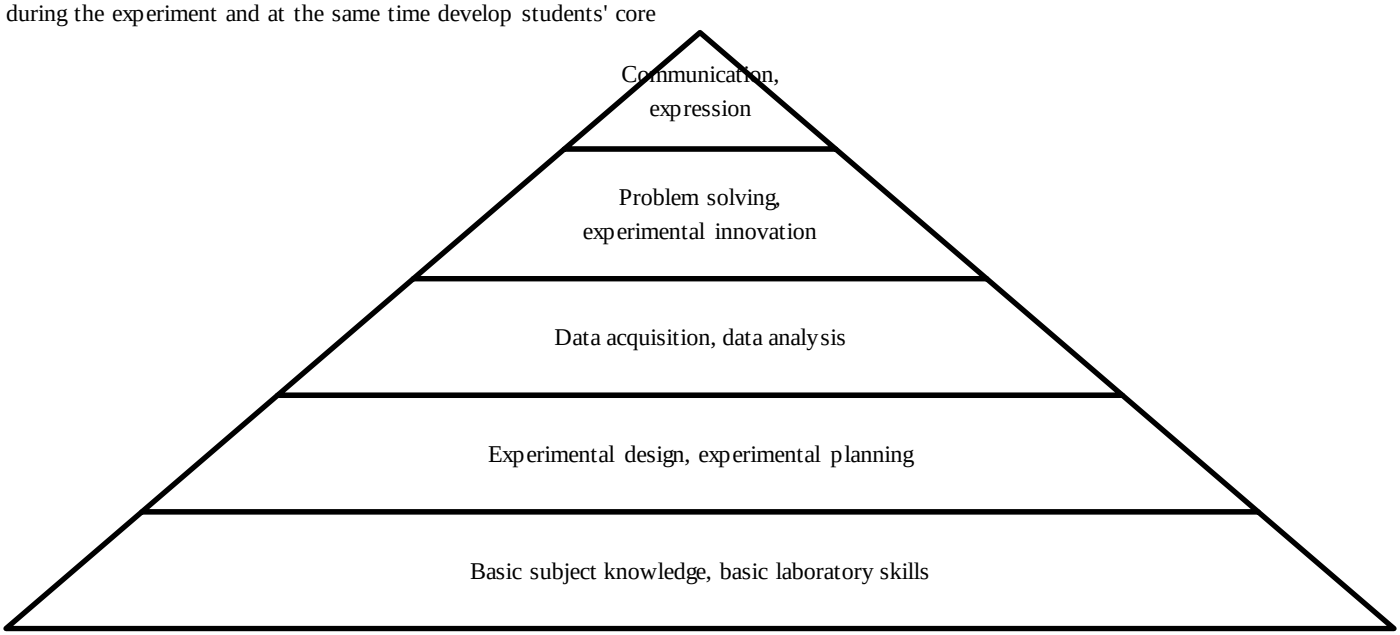


Figure 1 Pyramid of student capacity building

3.3. Development phase

3.3.1. Experimental development

In the process of innovative experimental development, teachers can stimulate students' innovative thinking and cultivate their spirit of scientific exploration and experimental design ability by guiding them to apply interdisciplinary knowledge to design new experimental schemes, utilize new materials or technologies, and explore new fields of application, among other teaching strategies. For example, students are instructed to try to use new materials or advanced experimental techniques to improve experimental methods, and to use zirconia oxygen analyzer, paramagnetic analyzer, tunable diode laser gas analyzer and other instruments to quantitatively detect the oxygen produced in this section of the experiment.

3.3.2. Mind Development

Laboratory teaching requires not only the development of experiments, but also the development of students' thinking is also a top priority. In the process of experimental teaching, teachers can skillfully use teaching strategies such as string of questions to come, guiding data analysis and interpretation, and organizing sharing and discussion between teachers and students after the experiment to stimulate students' thinking. For example, after students collect experimental data, they are guided to analyze and interpret the data, use statistical methods to compare the differences in the decomposition rate of hydrogen peroxide under different conditions, and try to explain the reasons for these differences, so as to cultivate their data analysis and reasoning thinking.

3.3.3. Capacity development

Effective experimental teaching not only exercises students' experimental skills, but also is an effective way to develop students' comprehensive ability. For example, by arranging students to work in small groups to solve problems encountered by students in the experimental process, it helps to cultivate students' problem-solving ability and adaptability, promotes cooperation and division of labor with others, and learns to communicate effectively, thus cultivating students' teamwork spirit and communication skills.

3.4. Implementation phase

In the implementation stage, teachers should try to avoid adopting a single teaching method, but diversify their teaching methods. Through diversified teaching methods, the learning needs and learning styles of different students can be better met, thus stimulating students' motivation to learn and improving teaching effectiveness.

DOI: 10.5281/zenodo.14160419

3.4.1. Project-based learning

Experiment design and execution are conducted as a project, and students work together in groups to complete the entire experimental process. For example, each group is responsible for designing a set of experimental solutions to solve the problem of non-flammable hygienic incense in the experimental process which leads to unknown experimental results, collecting and analyzing the solutions, executing the experimental operations, and finally sharing the results and summarizing the experience. Through project-based learning, students are able to improve their problem-solving and innovative thinking skills, laying a good foundation for future learning and career development.

3.4.2. Inquiry-based learning

This section of the experiment adopts an inquiry-based teaching method, in which the teacher provides the basic framework and guidance, and the students choose the experimental conditions and methods on their own. According to the experimental hypothesis to design verification experiments, the use of inquiry-based scientific method to design experiments, experimental operations and data collection, guiding students to explain the experimental data and experimental phenomena, helps to develop students' independent learning, practical ability and inquiry ability.

3.4.3. Interdisciplinary integration

Interdisciplinary teaching activities are designed by combining experimental content with knowledge from other disciplines. For example, applying chemical knowledge to analyze the catalytic mechanism of catalase, exploring the biological function and application of the enzyme, using mathematical knowledge to carry out the statistical analysis of the experimental data, as well as using physics to construct a model of catalase specificity. Through interdisciplinary integration, we expand students' horizons and promote their transfer and application of knowledge.

3.5. Evaluation phase

Effective evaluation methods can truly respond to the effectiveness of teaching and student learning, and the use of multidimensional evaluation can better reflect the effectiveness of teaching and learning, the following evaluation methods are provided for this lesson (Table 1).

Table 1 Evaluation dimensions of experimental teaching

Directions for Evaluation	Evaluation content	Evaluation criteria (compliance requirements)	Evaluation methods
Fundamental	To complete the inquiry experiments in the textbook independently, to master the methods of inquiry experiments, and to understand the relationship between independent variables, dependent variables and irrelevant variables.	Be able to complete the experiments in the textbook independently, master the independent variables, dependent variables and irrelevant variables, and explain the experimental phenomena and experimental results.	Lab Report Classroom Questions Classroom Observation
Foresight	Innovative experiments are forward-looking and prescient, providing new ideas for research in related fields.	The results of the experiment can have a significant impact on future research or applications.	Exchanges and Discussions Showcase
Innovative	The experiment used an innovative experimental design or methodology, introducing new influencing factors or novel materials, technology.	Improved or innovative technical solutions to problems or limitations of existing experiments.	Experimental Design Show results Exchange and Discussion Experiment report
Interdisciplinarity	Experimentation combines knowledge and techniques from multiple disciplines and crosses the boundaries of different disciplines.	Innovate existing experiments using knowledge and technology from multiple subject areas	Experimental program Experiment report Exchange and Discussion
Value	Experiments have teaching value, stimulate students' interest in learning and improve the quality of experimental. teaching	Improve students' scientific thinking, laboratory skills, creativity and scientific literacy.	Exchange and Discussion Presentation of results Evaluation Report Questionnaire

4. Conclusion

Experimental teaching is an important carrier of the teaching process of practical implementation, which plays a pivotal role in the cultivation of students' innovative thinking and the improvement of their ability to use their hands and brains. Based on the ADDIE model, the teaching design of "Comparison of Catalase Decomposition under Different Conditions" starts from the analysis of learners, educators and teaching contents, develops experimental resources in multiple ways, formulates teaching strategies, evaluates students' learning effects, and makes the design process more scientific, holistic and systematic, and transforms the "no attention, no experiment, no hands-on, no innovation". The design process is more scientific, holistic and systematic, so as to change the status

DOI: 10.5281/zenodo.14160419

quo of experimental teaching, which is “not emphasizing, not experimenting, not doing and not innovating”, to stimulate students' interest in learning biology experiments, to improve the effect of experimental teaching, and to promote the cultivation of students' core literacy in the discipline of biology.

Reference

1. 中华人民共和国教育部.普通高中生物学课程标准(2017年版2020年修订)[M].北京:人民教育出版社,2020:2.
2. 张剑锋.基于ADDIE模式的大学英语在线学习共同体构建[J].高教学刊,2020(31):96-99.

DOI: 10.5281/zenodo.14160419