



Practice and Innovation of High School Biology Teaching Based on the STEM Concept

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Abstract: High school biology teaching based on the STEM concept emphasizes the interdisciplinary integration of science, technology, engineering, and mathematics, aiming to enhance students' comprehensive abilities and innovative awareness. By incorporating interdisciplinary integration, problem-based learning (PBL), project-based learning (PBL), and deep application of information technology, this approach explores new pathways for practical teaching. Simultaneously, optimizing curriculum standards, integrating resources, deepening school-enterprise cooperation, and designing linked in-class and extracurricular activities provide effective strategies for promoting STEM education in biology teaching.

Keywords: stem concept, high school biology, teaching practice, interdisciplinary integration, innovative education

1. Introduction

This study explores the practice and innovative pathways of high school biology teaching based on the STEM concept, emphasizing the critical role of interdisciplinary integration of science, technology, engineering, and mathematics in teaching. By designing interdisciplinary teaching cases, employing problem-based and project-based learning strategies, and utilizing diverse information technology tools, it aims to enhance students' scientific inquiry abilities and interdisciplinary competence. The study also proposes implementation strategies such as optimizing curriculum objectives, integrating resources, fostering school-enterprise cooperation, and connecting classroom practice with real-world application. These approaches provide new insights and practical guidance for high school biology teaching innovation, fostering the comprehensive development of students' creativity.

2. High School Biology Teaching Practice Based on the STEM Concept

2.1 Interdisciplinary Teaching Design and Cases

2.1.1 Integration of Biology with Physics and Chemistry: Experimental Design for Cellular Metabolism

In teaching cellular metabolism, integrating biology with physics and chemistry deepens the understanding of energy transformation and material metabolism. For instance, during the study of ATP synthesis and decomposition, teachers can guide students to design experiments to analyze the effects of different temperatures and pH levels on enzyme activity, identifying optimal conditions for biochemical reactions. Coupled with knowledge of chemical reaction kinetics, students can also explore how changes in activation energy influence metabolic rates. This interdisciplinary experimental design not only strengthens students' understanding of biological concepts but also consolidates their knowledge of chemistry and physics.

2.1.2 Integration of Biology with Mathematics: Population Dynamics Modeling

The study of population dynamics involves mathematical tools such as calculus and statistics. Teachers can guide students through real-world cases, such as investigating predator-prey relationships in a specific region, to build mathematical models (e.g., the Lotka-Volterra model). Using real data, students perform calculations and simulation analyses. This hands-on activity demonstrates the application of mathematics in biology, cultivates logical thinking and data analysis skills, and deepens students' understanding of ecosystem balance[1].

2.2 Problem-Based Learning (PBL) Strategies

Problem-based learning (PBL) is a student-centered approach driven by complex, real-world problems. In a STEM-focused biology class, teachers can present open-ended questions such as "How can we address urban water eutrophication?" or "What are the potential impacts of gene editing on future agriculture?" Under the teacher's guidance, students work in groups to review literature, formulate hypotheses, analyze data, and propose solutions. This learning method cultivates students' scientific inquiry skills and teamwork while closely linking classroom knowledge to practical issues.

2.3 Implementation of Project-Based Learning (PBL)

Project-based learning engages students in long-term, comprehensive tasks, enabling them to participate deeply in solving complex problems. For instance, when studying genetic engineering, teachers can guide students to complete a project titled "Design a Drought-Resistant Genetically Modified Plant." Students research the biological mechanisms of drought-resistance genes, simulate experimental strategies for gene insertion, and perform virtual experiments. At the end of the project, students create presentation reports to share their findings. This teaching practice develops students' interdisciplinary skills, particularly their ability to tackle complex problems and foster innovative thinking.

3. Innovation in High School Biology Teaching Based on the STEM Concept

3.1 Innovation in Classroom Teaching Models

3.1.1 Application of Flipped Classrooms in Biology Teaching

The flipped classroom is a student-centered teaching model that redistributes the processes of knowledge delivery and internalization. In a STEM-based flipped classroom, students are tasked with previewing biology concepts independently using online courses or video lectures[2]. In-class activities then focus on group discussions, experimental design, or problem-solving under teacher guidance. This approach enhances student engagement and autonomy. For example, in teaching Mendelian genetics, teachers can assign tasks involving case studies of hereditary diseases within families. Students review materials and learn Mendelian laws before class, then engage in case discussions and model analyses during the lesson. This method not only deepens students' understanding of concepts but also develops their research thinking skills.

3.1.2 Research-Oriented Classroom Activities

Research-oriented classroom activities mimic authentic research processes, encouraging students to engage in problem identification, hypothesis formulation, experimental design, data analysis, and conclusion drawing. For instance, teachers can create a project titled "Exploring Factors Affecting Photosynthesis Efficiency in Plants." Students design their own experiments using provided equipment and plant materials, control variables, record data, and analyze results. Such activities cultivate scientific inquiry, teamwork, and critical thinking. Through this "learning by doing" approach, biology classrooms transform into platforms for exploration and innovation rather than mere knowledge delivery.

3.2 Transition from Single-Score Evaluation to Comprehensive Competency Assessment

Traditional biology assessments often focus solely on exam scores, neglecting other aspects of student performance. STEM-based evaluation emphasizes comprehensive abilities. For example, assessment weightings can include experimental operations, research reports, teamwork, and innovative thinking. In a project on "The Impact of Environmental Pollution on Aquatic Ecosystems," students might be evaluated on their ability to design experiments, analyze data, produce reports, and present findings. This approach not only reflects students' learning outcomes more accurately but also motivates them to demonstrate their abilities in various areas.

3.3 Establishing a STEM-Based Diversified Evaluation System

A diversified evaluation system incorporates both formative and summative assessments. Formative assessments span the entire teaching process, evaluating class participation, group collaboration, and intermediate achievements. Summative assessments focus on overall project quality and final reports[3]. For example, in a bioengineering design course, evaluation criteria could include the depth of biological knowledge application, the originality of technical solutions, engineering problem-solving abilities, and interdisciplinary collaboration skills. This comprehensive assessment method holistically evaluates student performance in STEM education and fosters their overall skill development.

The implementation of STEM concepts imposes higher demands on teachers' professional capabilities. High school biology teachers need to integrate interdisciplinary knowledge, design cross-disciplinary curricula, and guide practical activities. Schools can organize STEM teaching training programs covering curriculum design, teaching strategies, and innovative experimental skills. Additionally, establishing teacher learning communities to share successful experiences and cases regularly is an effective way to enhance teachers' abilities.

4. Conclusion

The practice and innovation of high school biology teaching based on STEM concepts contribute to deeply integrating interdisciplinary knowledge with teaching content, fostering students' problem-solving abilities and interdisciplinary thinking. By adjusting curriculum standards, optimizing teaching resources, deepening school-enterprise cooperation, and designing diverse practical activities, a comprehensive implementation pathway is constructed. This teaching model not only

promotes students' holistic development but also provides valuable insights for future educational reforms.

References

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