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Exploration of the Integration of STEM Education Concept into High School Biology Teaching

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Abstract: In China, STEM education is quietly emerging and has attracted extensive attention in the education field. As a new educational approach, it can not only fully mobilize students' enthusiasm for learning biology but also enrich classroom content, provide students with abundant learning resources, and enable them to explore biological knowledge independently. Currently, STEM education, which focuses on cultivating students' comprehensive qualities and innovative and creative abilities, has gradually become a trend in the reform of high school biology teaching methods. Therefore, the research on the integration of STEM and high school biology classrooms has important practical significance. This paper first briefly introduces the significance of integrating STEM and high school biology classrooms and then analyzes the effective strategies for this integration, aiming to provide new perspectives and methods for high school biology teaching, stimulate students' learning interests, improve the effectiveness of biology teaching, and inject new vitality into 21st-century STEM education.

Keywords: STEM education concept; High school biology; Teaching strategies

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1. Introduction

The current new curriculum reform has put forward the latest requirements for students' core qualities. In the past two years, the STEM education concept has gradually penetrated high school biology classrooms. The aim is to cultivate students' core qualities through cross-disciplinary integration, fully mobilize students' interest in learning biology, and promote their all-around development [1]. However, some teachers have not fully mastered the specific methods for effectively integrating STEM education into biology classrooms. It is hoped that the research of this paper can provide useful references for high school biology teachers in implementing STEM education during actual biology teaching. At the same time, it can give full play to the educational function of STEM education in cultivating students' biological core qualities [2].

2. The value of high school biology teaching based on the STEM education concept

The "STEM" education concept is a comprehensive education model that spans multiple disciplines such as science, technology, engineering, and biology. It especially emphasizes innovation, practice, and cross-disciplinary integration. In recent years, with the innovation of educational concepts, more and more educators have come to realize the significance of integrating STEM into high school biology classrooms [3].

Firstly, it helps to effectively enhance students' interest in learning biology. Traditional biology teaching often relies on classroom explanations and practice exercises, lacking practical operations and real-world applications. Students' understanding and memory of knowledge are often superficial, and they lack enthusiasm and interest in learning. However, STEM emphasizes practice, exploration, and innovation, encouraging students to understand biological knowledge through hands-on practice. This is not only conducive to cultivating students' practical abilities but also can greatly enhance their interest in learning biology [4].

Secondly, it helps to deepen and broaden the scope of biology teaching. Biology is a highly theoretical and abstract subject that often requires high-level logical analysis ability for in-depth understanding. STEM emphasizes cross-disciplinary integration, enabling students to deeply experience the internal connections between biology and other disciplines such as science, technology, engineering, and art while learning biology, which is beneficial for deepening and broadening their learning [5].

Finally, it helps to cultivate students' innovative thinking and innovative abilities. Influenced by STEM, the biology classroom is no longer just a place for imparting knowledge but rather a platform for students to practice, explore, and innovate. On this platform, students can not only understand biological knowledge more deeply through practical operations but also apply knowledge flexibly by solving real-world problems, thereby cultivating their innovative thinking and innovative abilities [6].

3. Analysis of the current situation and problems in high school biology teaching

3.1. Obvious textbook orientation

In terms of textbook orientation, the current high school biology textbooks have rigorous content design and strong systematicness, providing clear teaching objectives for teachers. However, the overly obvious textbook orientation also has certain limitations. On the one hand, excessive reliance on textbooks may lead to rigid classroom teaching activities, lacking flexibility and innovation, and failing to fully mobilize students' initiative and creativity. On the other hand, the update speed of textbook content lags behind the needs of the times, and it may not be able to reflect biological problems in modern science and technology and real life in a timely manner, which is not conducive to cultivating students' ability to solve practical problems and their cross-disciplinary literacy [7]. For a long time, teachers have been limited by such textbook content and tutoring materials, ignoring the importance of interesting teaching and students' learning processes. This should be optimized in the reform of high school biology teaching oriented by core qualities.

3.2. Single and inflexible teaching model

The single and inflexible teaching model is another challenge facing current high school biology teaching. Many classrooms still use the traditional lecture-based teaching method, with teachers as the dominant force and students in a passive receiving position. This one-way indoctrination teaching method often ignores the dominant position of students and their personalized needs [8]. Although some schools have started to try new teaching models such as interactive and inquiry-based teaching, in actual operation, they still struggle to get

rid of the pressure of exam-oriented education. As a result, the implementation of these new models remains superficial and fails to fully utilize their potential to stimulate students' interests and cultivate their thinking abilities. In the future, teachers should embrace new concepts and new technologies and widely apply them in practice to truly improve students' enthusiasm for learning, cultivate stronger thinking and innovative abilities, and contribute to the improvement of high school students' biology levels and their comprehensive and all-round development.

3.3. Inadequate construction of the teaching evaluation system

The inadequate construction of the teaching evaluation system is a key bottleneck restricting the improvement of high school biology teaching quality. Currently, the evaluation of students' biology learning mainly focuses on summative evaluation, such as mid-term and final exam scores, while less attention is paid to and applied in process-based evaluation. This "score-only" evaluation system is likely to cause students to memorize mechanically and pursue short-term results, ignoring the overall assessment of students' biological core qualities. In addition, the evaluation methods are relatively single, lacking a comprehensive evaluation of students' cooperation and communication skills, innovation abilities, and problem-solving strategies, and unable to comprehensively and accurately reflect students' learning progress and development potential. In other words, the incomplete construction of the evaluation system makes it difficult for students to receive positive feedback. If students get stuck in their own thinking, it will be even more difficult for them to improve their biology grades and levels, let alone achieve long-term development and progress.

4. High school biology teaching strategies based on the STEM education concept

4.1. Guided by diversified curriculum objectives to lead all-around development

From the perspective of STEM education, the goals of high school biology education are not limited to the imparting of biological knowledge and skills but should focus on guiding students' all-around development. To achieve this goal, high school biology teachers should consciously integrate the knowledge of multiple disciplines and fully demonstrate the comprehensive, open, practical, and exploratory characteristics of biology teaching. By setting multi-level and multi-field curriculum objectives, students can acquire a wider range of skills while learning, laying a foundation for cultivating their core qualities [9].

Thinking objectives: Different from the teaching objectives of traditional single-subject teaching, the biological education objectives based on STEM education should focus on cultivating students' thinking methods of flexibly applying biological knowledge and skills to solve complex, real-world problems, helping them master relevant methods. In addition, through a large number of biological practices and experiments, attention should also be paid to cultivating students' good emotional thinking and complex cognitive thinking [10].

Knowledge objectives: Knowledge objectives are of utmost importance in STEM education. Only when students master the basic facts and procedural knowledge of multiple disciplines, including biology, can they deeply understand and solve complex problems.

Ability objectives: The primary goal of biological education based on STEM education is to cultivate students' interdisciplinary comprehensive abilities and the ability to solve real-world problems. At the same time, it also focuses on cultivating their good teamwork spirit, laying a foundation for students' in-depth learning of biology.

Innovation objectives: Innovation objectives belong to high-level goals. The aim is to cultivate students' good innovative qualities by actively creating a strong innovation-culture atmosphere and formulating personalized training objectives, implementing high-quality education, thereby promoting the coordinated development of knowledge innovation and practical abilities, and leading the biology classroom towards an innovative path [11].

4.2. Developing a biological perspective by taking real-life situations as the carrier

STEM education emphasizes restoring biological knowledge to rich real-life situations, enabling students to have a more profound and comprehensive understanding of the origin and development of biological knowledge. Based on this, to broaden students' biological perspectives, guided by the STEM education concept, biology teachers should use real-world situations as carriers and carefully design situation-based tasks closely related to real life. For example, through diverse activities such as data analysis and model building, teachers can guide students to carefully observe the biological elements contained in real-life examples and naturally apply biological knowledge and skills, thus deepening their understanding of abstract biological knowledge [12]. This is conducive to developing students' biological abstract literacy on the one hand and enhancing their ability to observe the world from a biological perspective on the other hand, significantly improving the teaching quality. The basis and key to real-life situation teaching lie in the selection of real-life situations. An appropriate real-life situation can fit the teaching content, enabling students to have a more intuitive understanding and in-depth mastery of the knowledge they learn. At the same time, it is also an effective measure to mobilize students' learning enthusiasm and stimulate their learning interests. For example, when teaching the content of "sex-linked inheritance", the teacher can first pose a real-life-related question: "Classmates, do any of you have friends with red-green color blindness? Are they male or female?" Immediately, the classroom becomes lively, and students start discussing the question. After that, the teacher assigns an investigation task: "Investigate whether there are any red-green color-blind teachers and students in the school and classify the data." After forming research groups, students are full of enthusiasm. They divide tasks step by step, record carefully, and conduct extensive interviews to accurately screen out people with color-blindness genetic diseases. Finally, the teacher guides students to calculate the color-blindness incidence rates of male and female students respectively, based on the survey data and conduct a comparative analysis, closely integrating learning with life. By creating real-life learning situations, students can be influenced by knowledge imperceptibly, and their comprehensive abilities can be cultivated and exercised, which is conducive to laying a solid foundation for enhancing their core qualities. In addition, teachers can also complete the task of situation creation by combining social hot topics. Fundamentally, biological knowledge comes from life and is higher than life. The ultimate goal of students learning biological knowledge is to specifically solve a series of real-world problems. Therefore, teachers can precisely extract some biological knowledge points closely related to life around social hot topics, bringing students a new learning experience.

4.3. Relying on inquiry-based learning to strengthen thinking experiences

Cultivating students' scientific spirit and rational thinking is an important part of core qualities. Guided by the STEM education concept, in addition to emphasizing the deductive reasoning of knowledge and constructing a systematic biological knowledge system when cultivating students' biological core qualities, it is also necessary to cultivate students' ability to think about the world from a biological perspective [13]. Based on this, biology

teachers should rely on inquiry-based learning, carefully design open-ended questions and complex tasks, truly present the thinking process of students, and encourage them to conduct experiments bravely. Through a series of steps such as making hypotheses, conducting experiments, and verifying conclusions, students can independently discover and summarize laws, thereby strengthening their logical thinking, critical thinking, and creative thinking, and bringing them rich thinking experiences. For example, the content related to "cells" is the basis for learning and understanding biology. The teaching quality of this part is directly related to the depth and breadth of students' learning of subsequent content such as cell engineering and the conversion and utilization of cell energy. Therefore, it is important and necessary to improve the teaching quality of this part. In the actual teaching process, first, the author uses multimedia to display videos to let students visually experience the process of life from birth to growth. For example, by showing a video of a baby's birth, the author guides students to think about the question, "Where do humans come from?" This demonstration can help students better understand their origin and growth process. At the same time, students are encouraged to think and share their views with their deskmates and classmates sitting in front of or behind them. As the discussion deepens, the author finds that students will gradually extend this question to more biology-related questions, such as "Humans develop from cells", "So, where do cells come from?" etc. Combining the learned and unlearned relevant content, students will conduct scientific analysis and thinking and finally draw their own conclusions. From the analysis of the above-mentioned teaching segment, it can be seen that when students explore the question "Where do humans come from?", their thinking shows obvious characteristics, such as going from shallow to deep and from the surface to the essence. By guiding and inspiring students to explore independently and using heuristic questions in teaching, their thinking can become more scientific and rigorous during the research process. From the perspective of teachers' teaching, heuristic questions have outstanding teaching value. They can not only stimulate students' thinking but also guide students to conduct independent exploration. Through this process, students will acquire valuable scientific qualities, which are conducive to guiding students to move forward towards scientific truth and finally enabling them to gradually explore the true meaning of science.

4.4. Expanding and integrating off-campus resources to cultivate students' innovative spirit

Off-campus resources are an important supplement to high school biology teaching. Expanding and integrating off-campus resources can provide students with a broader learning space and practical opportunities. Schools can establish cooperative relationships with scientific research institutions, universities, enterprises, etc., and carry out extracurricular practical activities, allowing students to visit scientific research laboratories, production workshops, and other places to understand the practical applications of biological science [14]. For example, the school can cooperate with the local agricultural academy of sciences to organize students to visit the agricultural scientific research base, understand the planting techniques of crops, the methods of pest and disease control, and the application of biotechnology in agricultural production. It can also cooperate with universities to carry out biological popular science lectures, laboratory open-day activities, etc., and invite experts and scholars from universities to explain the cutting-edge knowledge and research results of biological science to students, stimulating their learning motivation and aspiration for further education. Schools can also organize students to participate in biological popular science exhibitions, biological competitions, etc., to broaden students' horizons and improve their comprehensive qualities. Biological popular science exhibitions usually display the latest research results of biological science, biodiversity protection, the application of biotechnology,

etc. By visiting these exhibitions, students can understand the development status and social applications of biological science, enhancing their understanding and interest in biological science. Biological competitions, such as the National High School Biology Competition and the International Genetically Engineered Machine Competition, are important platforms for cultivating students' innovative and practical abilities. During the process of participating in competitions, students need to apply the biological knowledge they have learned, combine the knowledge of multiple disciplines such as science, technology, engineering, and biology, solve real-world problems, design and implement experimental projects, and display their research results. Through competitions, students can not only improve their professional knowledge level but also cultivate teamwork spirit, innovative thinking, and practical abilities, laying a solid foundation for their future study and work [15].

5. Conclusion

In conclusion, with the further deepening of China's education reform, high school biology teaching is gradually developing from single-subject teaching to multi-disciplinary integrated teaching. Guided by the STEM education concept and aiming to cultivate students' core qualities, teachers should flexibly adopt diversified teaching strategies. For example, be guided by diversified curriculum objectives to lead all-around development; use real-world situations as carriers to develop biological perspectives; rely on inquiry-based learning to strengthen thinking experiences; expand and integrate off-campus resources to cultivate an innovative spirit, etc. Teachers should strive to build a biology classroom that integrates learning, doing, and understanding to promote the comprehensive development of students' knowledge and skills, learning attitudes, and values.

Disclosure statement

The authors declare no conflict of interest.

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