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Innovation and Assessment System for the Development of Biology Teaching Content Aligned with Sustainable Development Goals

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Abstract

With the in-depth promotion of the United Nations Sustainable Development Goals (SDGs), biology education plays a crucial role in the global education system by cultivating individuals with environmental awareness, ecological ethics, and social responsibility. This paper aims to explore how to systematically integrate the Sustainable Development Goals into biology education in China, proposing innovative strategies for teaching content and the construction of an assessment system based on these goals. Through literature research, case analysis, and theoretical simulation, this paper first outlines the theoretical foundations for teaching content innovation, including Education for Sustainable Development (ESD) and modern educational psychology theories. Subsequently, based on the three principles of "combining scientific and practical aspects," "balancing timeliness and foresight," and "coordinating systematic and open approaches," specific strategies for teaching content innovation are proposed. These strategies include the integration of cutting-edge knowledge, case-based teaching and situational creation, interdisciplinary fusion, and action-oriented learning. Additionally, this paper constructs a diversified assessment system that encompasses three dimensions: knowledge and skills, processes and methods, and emotional attitudes and values. It combines quantitative and qualitative assessment methods to ensure a comprehensive evaluation of students' overall competence in biology learning.

In the context of China's local educational landscape, this paper analyzes the current challenges faced by biology education, including curriculum standards, pressure from college entrance examinations, disparities in educational resources between urban and rural areas, and teacher training. It also proposes corresponding solutions. The research indicates that by implementing innovative teaching content and improving assessment systems, it is possible to effectively enhance students' subject literacy, ecological ethics, and social responsibility. This provides both theoretical support and practical guidance for the reform of biology education in China. Future research will aim to further develop the theoretical framework, optimize the assessment system, and explore the application of emerging technologies in teaching to promote the sustainable development of biology education on a global scale.

Keywords

Sustainable Development Goals, Biology Education, Innovative Teaching Content, Assessment Systems, Chinese Education Reform

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1. Introduction

1.1. Research Background and Significance

With the continuous advancement of the global Sustainable Development Goals (SDGs), biology education is playing an increasingly vital role in the global education system. As a fundamental discipline, biology not only serves as a key area for exploring the mysteries of life and understanding ecological principles, but it also significantly contributes to cultivating students' environmental awareness, ecological ethics, and social responsibility. Integrating sustainable development goals into biology education enables students to grasp the urgency of issues such as global biodiversity conservation, ecosystem stability, and sustainable resource utilization, thereby inspiring them to become active advocates and practitioners of sustainable development. This process is not only a crucial step in addressing the global ecological crisis and promoting social development but also contributes to nurturing a new generation of biology professionals with a global perspective and a strong sense of social responsibility(Jucker & Mathar , 2015).

Globally, many countries have gradually integrated the concept of sustainable development into their education systems. For instance, Finland's biology education framework fully incorporates content related to ecological protection and sustainable development, emphasizing problem-based learning (PBL) and inquiry-based learning to cultivate students' critical thinking and practical problem-solving skills. Finland's biology curriculum encompasses ecosystem services, species conservation, and the effects of global changes on ecology, enabling students to enhance their awareness of sustainable development not only through classroom instruction but also by actively participating in local ecological protection projects . In Canada, numerous university biology courses similarly focus on the integration of biotechnology and sustainable development, where students learn to address environmental and ecological challenges through hands-on experiences. These international experiences offer valuable insights for the reform of biology education in China(UNESCO , 2017).

In China, while biology education has incorporated some fundamental ecological and environmental knowledge, the "General High School Biology Curriculum Standards (2017 Edition)" underscores the importance of fostering students' social responsibility and practical skills. However, the systematic integration of sustainable development concepts into the curriculum—particularly regarding teaching content and assessment systems—remains a pressing issue. Current instruction primarily emphasizes basic biological theories and experimental skills, often neglecting in-depth discussions on ecological ethics, global environmental challenges, and sustainable development. Furthermore, influenced by the college entrance examination system and the pressures of academic advancement, many schools tend to prioritize exam-oriented education. This focus presents challenges such as inadequate teacher training, limited curriculum resources, and a singular evaluation method, all of which hinder the effective implementation of sustainable development education in daily teaching practices(W & Li, 2023).

Researching innovative approaches to biology teaching content and developing an educational model that aligns with sustainable development goals is of significant academic and practical importance. This study aims to explore the integration of sustainable development goals into biology education, propose innovative strategies for teaching content and assessment systems based on these goals, and analyze their feasibility and challenges within the local educational context in China. Through practical case studies and theoretical discussions from multiple schools, this research will evaluate the impact of these reform initiatives on students' subject literacy, experimental skills, and sense of social responsibility, while also offering actionable recommendations for future reforms in biology education(Mikkonen et al ,2020).

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1.2. Current Research Status Domestically and Internationally

In the field of biology education, particularly concerning the integration of sustainable development goals into teaching content and assessment systems, there have been preliminary explorations both domestically and internationally. Some foreign education systems, such as those in Finland and Canada, have successfully incorporated themes of ecological protection and sustainable development into biology instruction. They have enhanced educational quality through innovative teaching methods and assessment strategies(Zhang, L , 2022).

As a leader in global educational reform, Finland's education system emphasizes student-centered teaching methods and interdisciplinary integration. Finnish biology education, in particular, focuses on incorporating concepts of environmental protection and sustainable development. For instance, the University of Helsinki has implemented project-based learning (PBL) within its biology curriculum, allowing students to not only study ecosystem theory but also actively engage in local ecological restoration and species conservation projects. This approach effectively connects practical experience with theoretical knowledge (Mikkonen et al., 2020). Consequently, this educational model enhances students' environmental awareness and social responsibility while fostering their critical thinking and innovative abilities.

Canada strengthens the connection between biology and other disciplines, such as environmental science and sociology, through its interdisciplinary education system. For instance, the biology curriculum at the University of British Columbia integrates topics such as sustainable agriculture, ecological restoration, and environmental ethics. This approach allows students to engage in local community environmental protection projects while learning biological theories, thereby addressing ecological issues in a practical manner. This teaching model not only cultivates students' professional skills but also enhances their capacity and motivation to tackle global environmental challenges(UNESCO , 2014).

In contrast, while China's biology education has made some progress in teaching content and experimental skills, it still falls short in integrating sustainable development goals. On one hand, curriculum objectives typically emphasize the mastery of fundamental knowledge and experimental skills, neglecting the deeper connections between biology and social and environmental issues. On the other hand, the assessment system for teaching often employs a singular evaluation method for assessing students' social responsibility and ecological ethics, making it difficult to effectively measure their growth in sustainable development literacy. Particularly in the context of the uneven distribution of educational resources between urban and rural areas, as well as significant regional development disparities, promoting the adaptive integration of sustainable development goals into biology teaching based on local educational realities remains a complex and urgent challenge(Burmeister et al , 2012).

1.3. Research Methods and Approaches

This study aims to explore innovative strategies for teaching biology content based on sustainable development goals, utilizing the following research methods:

Literature Review: This section involves an examination of innovative practices and theoretical foundations in both domestic and international biology education. The aim is to clarify the current application status and identify shortcomings related to the integration of sustainable development goals in biology teaching. A systematic search of domestic and international journal articles, educational policy documents, and various research reports will establish a robust theoretical foundation for the study.

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Case Analysis: This process involves selecting representative schools and educational institutions, or publicly reported teaching reform cases, to analyze their practical experiences in content innovation, teaching methods, and assessment systems. The goal is to extract successful elements and transferable experiences. For cases from local Chinese schools, particular attention will be given to their specific operations in teacher training, curriculum resource development, and changes in evaluation methods(Shepard , 2000).

Empirical Research (or Theoretical Simulation): Depending on the specific conditions of the research, innovative teaching and assessment systems can be implemented across multiple schools to investigate and analyze their effects. A comprehensive evaluation of the impact of teaching reforms will be conducted using a combination of quantitative and qualitative methods. If actual conditions are constrained, "theoretical simulation" or "small-scale pilot" approaches can be employed to gather both quantitative and qualitative data, such as changes in students' cognitive levels, teacher feedback, and student survey results. This data will support the demonstration of the feasibility and value of the reforms(Burmeister et al , 2012).

Through these methods, this study will thoroughly investigate the development and implementation of innovative biology teaching content and assessment systems grounded in sustainable development goals. It aims to provide both theoretical support and practical guidance for the reform of biology education in China.

2. Theoretical Foundation for Innovative Biology Teaching Content Based on Sustainable Development Goals

2.1. Theory of Sustainable Development Education

The theory of sustainable development education emphasizes the cultivation of students' knowledge, skills, attitudes, and values essential for achieving sustainability. The educational objectives guided by this theory encompass not only the transmission of knowledge but also the development of students' awareness and capacity for action concerning environmental, social, and economic sustainability issues. In the context of biology education, this theory offers teachers a framework to align the biology curriculum with sustainable development goals. For instance, when teaching about ecosystem services, educators should not only help students grasp the scientific principles underlying these services but also guide them in recognizing their significance for global sustainable development. Furthermore, teachers should encourage students to understand how to protect the ecological environment through responsible resource use and ecological restoration(Tilbury , 2011).

The theory of sustainable development education necessitates that educators move beyond traditional methods of knowledge transmission and embrace more flexible teaching approaches, such as project-based and inquiry-based learning. These methods enable students to comprehend and address ecological and environmental challenges through practical activities and social engagement (Sterling , 2010). By employing such pedagogical strategies, students can link the biological knowledge they have acquired with social and environmental issues, gradually internalizing a sense of responsibility and agency. This, in turn, empowers them to contribute their insights and efforts toward sustainable social development(Holbrook & Rannikmae , 2009).

2.2. Modern Educational Psychology Theories

Constructivist theory in modern educational psychology posits that learning is an active process of constructing knowledge based on prior experiences. In the context of biology education, this theory

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emphasizes the importance of creating rich learning environments and presenting real-world problems to guide students in their exploration and problem-solving efforts. For instance, teachers can facilitate students' understanding of biological principles by simulating dynamic changes in ecosystems or organizing field trips. Through cooperative learning and team discussions, students can share knowledge, engage in meaningful interactions, and reflect deeply on biological phenomena and the scientific principles that underpin them(Leach & Scott , 2002).

Additionally, the theory of multiple intelligences posits that educators should consider individual differences among students throughout the teaching process. This involves designing a variety of learning tasks, such as biology experiments, role-playing activities, and interdisciplinary projects, to address diverse learning needs and stimulate each student's potential. Through this personalized approach to teaching, students can not only achieve a comprehensive understanding of biological concepts but also apply this knowledge in real-life situations to tackle complex ecological and environmental challenges(Bybee , 2010).

3. Innovative Strategies for Teaching Biology Content Aligned with Sustainable Development Goals

Innovative biology teaching content based on the Sustainable Development Goals (SDGs) should be informed by the theory of Education for Sustainable Development (ESD) and contemporary educational psychology. This approach emphasizes three main principles: "combining scientific rigor with practicality," "balancing timeliness with foresight," and "coordinating systematization with openness." The following sections will provide a more detailed and comprehensive explanation of these three principles and propose actionable theoretical guidance.

3.1. Principle of Combining Scientific Rigor with Practicality

3.1.1. Theoretical Connotation

- Scientific Rigor: As a natural science, biology must rely on the latest research findings and academic advancements to ensure the accuracy, systematic organization, and contemporary relevance of the teaching content.

- Practicality: Biology plays a crucial role in addressing sustainable development issues, including resource management, environmental protection, and ecological restoration. Consequently, biology education should closely integrate with real-world problems to enhance students' practical application skills and foster a sense of social responsibility (National Research Council , 2009).

3.1.2. Implementation Strategies

Incorporating Cutting-Edge Knowledge

Teachers should consistently monitor leading biology journals, academic conferences, and emerging research trends. They should promptly integrate cutting-edge knowledge, such as gene editing (CRISPR-Cas9), synthetic biology, and bioinformatics, into the curriculum.

- Designing Thematic Modules: In the course schedule, establish a thematic module titled "Overview of Cutting-Edge Biology" to enhance students' understanding of the latest research trends and application scenarios in the field of biology, thereby stimulating their interest in learning.

Case-Based Teaching and Context Creation

- Introducing Real Cases: Topics such as global warming, significant reductions in biodiversity, and disease prevention can be structured for group discussions or scenario simulations. This approach

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enables students to enhance their scientific inquiry and practical skills while addressing real-world challenges.

- Writing Contextualized Teaching Materials: In textbooks and teaching resources, incorporate virtual scenarios and real news reports to stimulate students' critical thinking. This approach enables them to apply biological principles to analyze, discuss, and propose solutions.

Interdisciplinary Integration

- Intersection with Environmental Science: In teaching segments on ecology and environmental protection, introduce case studies such as water resource management, air pollution control, and waste resource utilization to explore the interdisciplinary applications of biology and environmental science.

- Intersection with Social Sciences: Discuss the ethical issues arising from biotechnology, including gene editing and cloning technologies. This will enable students to assess the impact of technological advancements on humanity and the environment from sociological and ethical perspectives(Mikkonen et al , 2020).

Action-Oriented Learning

- Designing Simulated or Theoretical Projects: Although real-world practices may not be conducted, teachers can guide students in designing "virtual" social practice or ecological restoration projects. For instance, they can simulate an ecosystem restoration plan in class, encouraging students to consider how to manage species diversity and allocate resources. This approach fosters their ability to apply knowledge comprehensively and enhances their innovative thinking.

In the local educational context in China, the following points require further consideration:

- Curriculum Standards and College Entrance Examination Pressure: When introducing cutting-edge knowledge or case studies, teachers must align with the requirements of the "General High School Biology Curriculum Standards (2017 Edition)" to ensure a balance between students' mastery of fundamental concepts and their preparation for the college entrance examination.

- Utilization of Regional Featured Resources: For instance, in coastal areas, prioritize marine ecological protection; in central regions, integrate the sustainable development of agricultural ecosystems; and in western regions, focus on desertification prevention. Fully leverage local resources and environmental characteristics in project design or case studies to enhance practical value and relevance(Johnson et al , 2015).

3.2. Principle of Balancing Timeliness and a Forward-Looking Perspective

3.2.1. Theoretical Connotation

Timeliness: Given the rapid advancements in biotechnology and information technology, educational content must be continuously updated to align with contemporary scientific trends and societal needs. This ensures that the material remains engaging for students and retains its practical significance in education (Shepard , 2000).

- Forward-Looking Perspective: As biology plays a crucial role in future technological innovations, education should guide students in understanding potential developmental directions and long-term impacts. This approach fosters innovative thinking and promotes awareness of sustainability for the future.

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3.2.2. Implementation Strategies

Cutting-Edge Technology Topics

- Update scientific hotspots each semester: Incorporate modules such as "Biology Frontier Forum" or "Future Trends in Biology" into the curriculum outline. These modules will provide a platform for educators to discuss significant research achievements or socially relevant biological events (e.g., new vaccine development) that emerge throughout the semester.

- Expert Reports and Online Resources: Invite university researchers or industry experts to share the fundamental principles, recent advancements, and potential applications of cutting-edge technologies online. This initiative aims to stimulate students' interest in research and innovation.

Discussions on Scientific Ethics and Social Responsibility

- Gene Editing and Social Reflection: Organize classroom debates or essay writing assignments that enable students to assess the advantages and disadvantages of gene editing technology from various perspectives, including scientific principles, ethics, legal considerations, and social impact. This approach fosters interdisciplinary analytical skills.

- Long-term Impacts of Emerging Biotechnologies: Encourage students to consider the question, synthetic biology is implemented on a large scale, what would be its ecological and social impacts? them develop a long-term vision for sustainable development (Wiek et al ,2011).

Virtual Reality (VR) and Simulation Experiments

- VR Course Assistance: Utilize virtual reality technology to simulate complex ecosystems or advanced laboratory environments, enabling students to observe and engage with biological phenomena in an immersive context.

Teachers can design "virtual experimental data" for students to analyze using statistical and bioinformatics methods, thereby enhancing their critical thinking and digital skills through simulation experiments and data analysis.

In the context of China, it is essential to pay attention to:

- Disparities in the level of educational informatization exist: Eastern regions and prominent schools may be equipped with virtual reality laboratories or advanced technological facilities, whereas some remote areas or under-resourced schools still face considerable deficiencies in hardware. Consequently, appropriate teaching methods should be selected based on the specific circumstances of each school to prevent an over-reliance on expensive equipment, which could impede the progress of educational reforms.

- Integration of Policies and Social Hotspots: For instance, the varying phased policy orientations in China concerning genetically modified crops and ecological agriculture, along with the public's understanding and acceptance of gene editing and artificial breeding, are significant factors.

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Educators can effectively introduce debates and discussions on these social issues, guiding students to develop rational, critical, and multidimensional perspectives(Merchant et al , 2014).

3.3. Principles of Coordinating Systematic and Open Approaches

3.3.1. Theoretical Connotation

Teaching content should progress systematically from fundamental biological concepts to advanced applications, enabling students to develop a comprehensive knowledge framework.

Within the systematic framework, allocate space for students to explore independently and personalize their learning, fostering diverse thinking and individual development.

3.3.2. Implementation Strategies

Hierarchical Course Content

- Three-Tier Structure: Organize textbook content into three levels: Basic Biology (cell biology, genetics, etc.), Advanced Biology (molecular biology, microbiology, etc.), and Cutting-Edge Biology (gene editing, synthetic biology, etc.). This approach progressively enhances students' understanding of biological concepts.

- Clearly define key concepts and main themes: Emphasize core concepts and critical issues (e.g., "biodiversity," "biological evolution, and at each level to ensure that students master and thoroughly understand essential knowledge points(Barth & Michelsen , 2013).

Open Learning Modules

- Self-Selected Topic Research: In addition to the mandatory foundational courses, establish a variety of sustainable development topics (e.g., "Agriculture and Biotechnology," "Urban Ecological Management," "Extreme Environments and Biological Adaptation") for students to select from based on their interests, allowing for deeper exploration.

- Interdisciplinary Elective Courses: Collaborate with various fields, including environmental science, sociology, and economics, to encourage students to engage in interdisciplinary courses such as "Environmental Planning" and "Technology Innovation and Ethics" during the elective phase. This approach fosters multidimensional perspectives among students.

Support System for Independent Learning

- Online Learning Platform: Develop an online resource library that includes literature, video courses, datasets, and other materials for students to access for supplementary learning tailored to their individual needs, facilitating personalized exploration.

- Mentorship and Teaching Assistant Support: Encourage teachers and teaching assistants to offer regular consultations and guidance to students.

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Answer questions and offer research ideas or resource suggestions to enhance students' ability to learn independently.

Learning Communities and Cooperative Learning

Online and Offline Learning Communities: Encourage students to form study groups to collaborate, share insights, and engage in discussions through both online platforms and offline seminars.

Collaborative Assessment: Incorporate peer evaluation or collaborative assessment into evaluations, enabling students to reinforce their knowledge through sharing and discussion while fostering a spirit of teamwork.

In the context of China, additional recommendations include:

Development of School-Based Curriculum and Regional Collaboration:Within the framework of national curriculum standards, encourage schools and regional education administrative departments that possess the necessary resources to develop localized school-based curricula or regional collaborative courses. For instance, design interdisciplinary inquiries or thematic research projects that address local ecological issues, such as water resource shortages and deforestation(Wals & Corcoran , 2012).

Teacher Training and Resource Sharing: Open learning necessitates that educators possess well-developed guidance and management skills. It is advisable for regional research platforms to regularly conduct teacher training sessions, enabling educators to share high-quality resources and teaching designs. This approach fosters a collaborative community that continuously advances the implementation of sustainable development education concepts.

4. Assessment System for Biology Education Based on Sustainable Development Goals

To comprehensively assess students' learning outcomes and overall competencies in biology education aligned with sustainable development goals, it is essential to develop a scientific, systematic, and hierarchical assessment framework. This framework should encompass not only the evaluation of knowledge and skills but also emphasize multiple dimensions, including processes and methods, emotional attitudes, and values. Furthermore, it should promote diversity and multidimensionality in assessment approaches.

4.1. Design of the Assessment Indicator System

In the assessment system for biology education aligned with sustainable development goals, the assessment indicators should encompass three major dimensions: knowledge and skills, processes and methods, and emotional attitudes and values. The following sections further refine the connotations and levels of assessment indicators in conjunction with Education for Sustainable Development (ESD) and contemporary educational psychology theories(Sadler , 1989).

Knowledge and Skills Dimension

Mastery of Fundamental Knowledge: This encompasses concepts, principles, and laws in essential areas of biology, including cell biology, genetics, and ecology.

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Understanding Cutting-Edge Knowledge: Assessing students' foundational comprehension of advanced fields such as gene editing, synthetic biology, and bioinformatics.
- Comprehensive Analysis and Problem Solving: The capacity to utilize biological knowledge to assess practical issues within theoretical frameworks and to propose viable solutions.

Processes and Methods Dimension

- Scientific Thinking and Research Methods: The ability of students to demonstrate critical thinking, inquiry-based reasoning, and a comprehensive understanding and application of scientific methods, including experimental design and data analysis, when addressing biological issues.
Independent Learning and Information Acquisition: The ability to acquire biological knowledge from literature, databases, and multimedia sources, as well as to discern, integrate, and apply this knowledge effectively.
- Teamwork and Communication: The ability to collaborate effectively with others during group discussions or theoretical project designs, while clearly and accurately expressing viewpoints in theoretical reports or presentations.

Emotional Attitudes and Values Dimension

- Environmental Protection and Ecological Ethics Awareness: This refers to the extent to which students are consciously aware of environmental issues and exhibit a positive attitude toward ecological protection and the preservation of biodiversity.
- Recognition of Sustainable Development Concepts: The degree of understanding of the Sustainable Development Goals (SDGs) and attitudes toward related issues, such as resource allocation and climate change.
- Sense of Social Responsibility and Global Perspective: A comprehensive understanding of how personal behavior affects social and ecological systems, a commitment to taking responsibility for social and environmental well-being, and an initial global perspective(Shepard , 2000).

In the context of Chinese education, it is essential to integrate:

- Connection with the College Entrance Examination Evaluation System: Although the national level has not yet introduced sustainable development-related questions on a large scale in the college entrance examination, some provinces and cities have initiated pilot educational reforms or school-based assessments in this area. It is important to explore how to shift the focus of assessment from "rote memorization" to "comprehensive analysis and value judgment. students to consciously engage with ecological and sustainable issues while preparing for their exams(Shavelson et al , 1999).

4.2. Assessment Methods and Tools

In practical application, the assessment system should integrate both quantitative and qualitative evaluations to achieve a comprehensive understanding of students' performance in knowledge, skills, and values. The following are additional refinements and enhancements:

Quantitative Assessment Methods

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Comprehensive questions can be included in written and computer-based exams, such as monthly tests, mid-term assessments, or final exams. These questions may incorporate real-life scenarios, such as "urban river pollution, to evaluate students' ability to apply biological principles, environmental protection measures, and sustainable development strategies.

2. Standardized Assessments: In addition to traditional test papers, modular assessment question banks can be made available through online learning platforms to continuously monitor students' mastery of advanced knowledge, such as gene editing ethics and ecological agriculture.

3. Questionnaire Surveys: In China, scales can be developed that incorporate environmental attitude scales (such as the revised New Ecological Paradigm (NEP) scale) and social responsibility scales. These scales utilize Likert scales for quantitative analysis, allowing for comparisons of results across different semesters or academic years to identify trends in student attitudes(Savery , 2006).

Qualitative Assessment Methods

1. Classroom Observation and Recording: Teachers or teaching assistants can utilize "classroom observation scales" to document students' discussions and interactions, including aspects such as participation, depth of thought, and teamwork strategies. This information can be compiled into periodic evaluation reports.
2. Student Interviews and Group Reports: Semi-structured interview outlines can be utilized during interviews to gather qualitative information regarding students' understanding of sustainable development goals, shifts in attitudes toward environmental issues, and interest in biology education.
3. Peer and Teacher Evaluations: In theoretical project design or case analysis, key indicators—such as "creativity in problem-solving," "logical reasoning in argumentation," and "effectiveness of teamwork be established for scoring and feedback by both teachers and group members.

Diverse Data Integration

1. Learning Portfolios (e-portfolios): Students are encouraged to upload process-related materials, such as reading notes, project proposals, and experimental design ideas, that pertain to themes of sustainable development onto an online platform. Teachers provide regular feedback to assist students in reflecting on their work and making improvements.
2. Digital Learning Platform Records: By utilizing smart campus platforms (such as Rain Classroom and Chaoxing Learning Pass), which are employed by numerous educational institutions, it is possible to track student learning behavior data. This data includes metrics such as progress in viewing instructional videos, frequency of online discussions, and assignment submission status. Additionally, data analysis tools, such as learning analytics dashboards, can generate visual reports for both students and teachers (Winarno & Gadzali , 2025).

4.3. Feedback and Application of Assessment Results

The value of assessment extends beyond the objective measurement of students' learning outcomes; it also encompasses the provision of timely and effective feedback to students, teachers, and school management stakeholders. This feedback facilitates the continuous improvement of teaching content and methods (Merchant et al , 2014).

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Student Level

- Personalized Feedback Reports: Based on the results of various assessment tools, personalized feedback reports can be generated to help students identify their strengths, weaknesses, and areas for improvement.
- Improvement of Learning Strategies: Based on feedback reports and teacher suggestions, students can modify their learning strategies and broaden their learning resources to further enhance their performance in knowledge, skills, and values.

Teacher Level

- Adjusting Teaching Design: Educators can modify the difficulty of their instruction, optimize the pace of teaching, or introduce contemporary topics based on student assessment results to accommodate diverse learning needs.
- Targeted Guidance: For students with learning difficulties or those in need of guidance in values, teachers can offer targeted support by providing additional learning resources or conducting group and individual tutoring sessions.

Management and Decision-Making Levels

- Course and Textbook Improvement: Assessment results can serve as a foundation for schools or research departments to enhance curriculum outlines and textbook content, ensuring they are better aligned with sustainable development goals and the latest advancements in biology.
- Educational Resource Allocation: By analyzing multiple batches of assessment data, management can identify areas of weakness in biology instruction and allocate funds and resources accordingly—such as purchasing virtual experimental equipment and enhancing teacher training—to improve overall teaching quality.

In providing specific feedback and its application, attention should be given to:

- Differentiated Feedback: The interpretation and application of assessment results should reflect differentiation based on the specific conditions of various regions, schools, and classrooms. In areas with limited resources, priority should be given to addressing gaps in teacher training and essential experimental equipment. Conversely, in regions with more favorable educational conditions, higher-level reforms, such as the promotion of virtual reality (VR) laboratory construction and interdisciplinary collaboration, can be further advanced(Johnson et al , 2015).

- Involvement of Society and Parents: In certain practical or theoretical design projects, parents and community representatives can be invited to participate in reporting or presentation activities. This involvement enhances societal awareness of sustainable development education and fosters a collaborative effort.

4.4. Table of Assessment Indicator System

In order to demonstrate the assessment indicator system more intuitively, the following table summarises the specific assessment indicators for each dimension and their corresponding assessment methods.

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Table 1 Indicator system for assessing biology teaching

Assessment dimensions	Specific indicators	Assessment methodology
Knowledge and skills	Knowledge acquisition	Midterm and final exams, unit tests
	Experimental design and data analysis skills	Lab report grading, lab operation assessment
	Practical problem-solving skills	Project design and implementation, case studies
Processes and methods	mindset	Transcripts of classroom discussions, mind-mapping analyses
	Ability to select and apply methods	Evaluation of the project implementation process, use of experimental methods
	Teamwork skills	Group project scoring, team role assignment and collaboration
Affective Attitudes and Values	Environmental Consciousness	Questionnaire results, class discussion performance
	Recognition and internalisation of the concept of sustainable development	Student interviews, Attitude Change Scale scores
	sense of social responsibility	Records of students ' participation in environmental actions and records of teachers' observations

5. Research Outlook

5.1. Deepening and Expanding the Theoretical Framework

Future research can further advance the theory of innovative biology teaching content grounded in sustainable development goals, particularly through the integration of emerging disciplines such as bioinformatics, synthetic biology, and synthetic ecology(Akpınar & Atak , 2025). By incorporating multidisciplinary theories, a more comprehensive and systematic framework for the innovation of teaching content can be developed, thereby enhancing both the theoretical depth and breadth of biology education(Tilbury , 2011).

5.2. Optimizing and Enhancing the Assessment System

The assessment system requires ongoing optimization, which includes the integration of diverse sources of assessment data, such as feedback from employers and evaluations from third-party organizations. This approach will provide a more reliable foundation for teaching decisions. By merging theoretical frameworks with practical applications, we can enhance the development of assessment indicators and the design of assessment methods, thereby ensuring the scientific validity and effectiveness of the assessment system(Dede , 2009). It is crucial to actively pursue long-term tracking studies across various regions and educational stages in China, such as longitudinal studies that follow students from middle school through high school to university. This will enable a more

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comprehensive evaluation of the mechanisms and influencing factors that contribute to the development of students' sustainable competencies(Shepard , 2000).

5.3. Cross-Cultural Comparative Research

Through cross-cultural comparative research, exploring innovative practices and outcomes in biology education across various countries and regions can offer valuable perspectives and experiences for the advancement of global biology education(Jucker & Mathar , 2015). Specifically, examining the differences in cultural backgrounds, educational policies, and resource allocation can enhance our understanding of how to effectively integrate sustainable development goals in diverse contexts, thereby providing insights for global biology education reform. In the case of China, conducting in-depth comparisons with educational practices in countries along the "Belt and Road can reveal common challenges and opportunities for collaboration in sustainable development education(Mikkonen et al , 2020).

5.4. Theoretical Exploration of Technological Methods

Future research should also enhance the theoretical exploration and application of technological tools, such as data mining and artificial intelligence, to analyze students' learning trajectories and further optimize personalized learning plans. It is crucial to investigate how to theoretically integrate emerging educational technologies to improve the theoretical framework for innovative biology teaching content(Jarry & Cohen , 2025). For instance, employing machine learning algorithms for the automated evaluation of students' assignments or discussion records can alleviate the workload for teachers while providing students with timely and accurate feedback(Amina & Mustapha , 2025).

6. Conclusion

Through theoretical innovations in teaching content and assessment systems, this research proposes a reform plan for biology education based on sustainable development goals. Grounded in the theories of sustainable development education and modern educational psychology, this paper emphasizes the scientific, practical, contemporary, and forward-looking aspects of biology instruction. Addressing the local educational context in China, it further analyzes the challenges teachers encounter in implementing reforms amid the pressures of curriculum standards and college entrance examinations. Additionally, it highlights pressing issues such as the uneven distribution of educational resources between urban and rural areas, inadequate teacher training, and a singular evaluation approach(National Research Council , 2009). By proposing more targeted strategies for innovating teaching content and assessment systems, this research offers valuable theoretical support and practical guidance for future reforms in biology education(Sterling , 2010).

Despite certain challenges related to educational resources, teacher training, and technological applications, the innovative teaching strategies and assessment systems proposed in this paper present new ideas for reforming biology education within the local context in China. Future research should aim to further explore these theoretical discussions and utilize emerging technologies and interdisciplinary collaboration to foster the sustainable development of biology education on a global scale, ultimately enhancing students' competencies in sustainable development comprehensively.

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