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On the integration of biology competition content with conventional classroom teaching

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Abstract. Against the dual backdrop of the "Double Reduction" policy and the reform of basic education oriented toward core competencies, biology competitions have, by virtue of their depth of knowledge, inquiry-based nature, and practice-oriented advantages, become an important vehicle for compensating for the limitations of conventional classroom teaching and promoting students' comprehensive development. Based on the author's years of experience in systematic training for biology competitions and conventional classroom teaching, and drawing on constructivist learning theory, the STEAM education concept, the STS education ideas proposed by Jianjun Li and others, as well as the elite talent cultivation model constructed by Cai Chen, Nie et al., this study systematically explores the integration mechanism of biology competition content with conventional classroom teaching from four dimensions: theoretical foundations, educational value, practical pathways, and case validation. The study proposes a four-in-one integration model of "content reconstruction—method innovation—evaluation optimization—resource integration", which seeks to achieve complementary advantages between competition-based education and regular teaching by selecting competition-relevant content, innovating teaching methods, improving evaluation systems, and integrating high-quality resources. Practice shows that this integration model can effectively stimulate students' interest in biology, enhance scientific thinking and inquiry abilities, and simultaneously support the professional development of teachers and the improvement of the curriculum system, providing an actionable reference for the reform of science education in secondary schools.

Keywords: biology competition, conventional classroom teaching, teaching integration, STS education, elite talent cultivation

1. Introduction

With the successive implementation of the *Compulsory Education Biology Curriculum Standards (2022 Edition)* and the *General Senior High School Biology Curriculum Standards (2017 Edition, Revised 2020)* [1], the cultivation of core competencies has become the central goal of secondary school biology education, requiring a shift from "knowledge transmission" toward "ability development" and "competency formation". The *National Middle School Biology League and Competition Regulations (Draft)* explicitly states that biology competitions, as a supplement and development of in-class biology education, are fundamentally aimed at stimulating students' learning interest, cultivating scientific abilities, and promoting the reform of biology education [2]. Conventional biology classroom teaching, constrained by class schedules, textbook systems, and the class-based teaching structure, often faces issues such as insufficient depth of knowledge, limited inquiry-based activities, and difficulty meeting students' individualized needs. In contrast, biology competitions, grounded in core life science knowledge, emphasize the training of scientific thinking, the development of experimental inquiry skills, and the construction of knowledge systems. Their content spans core areas such as cell biology, genetics, and ecology, incorporating both advanced knowledge and practical skills, thereby effectively addressing the shortcomings of conventional teaching [3].

Internationally, the integration of biology competitions with conventional teaching has matured. Research by Ozdemir et al. on countries such as Turkey and South Korea indicates that preparation for the International Biology Olympiad (IBO) can significantly enhance regular biology classes, improving students' experimental skill qualification rates by 20%, offering a useful reference for relevant practices in China. Jianjun Li and Zeyong Zhang [4], in *Application of STS Theory in Biology Competitions*, emphasize that the core function of biology competition education is quality-oriented education. Integrating STS educational concepts into competition training promotes the holistic development of students' knowledge, abilities, and character. Chen, Cai, Nie, and colleagues [5], through analysis of the growth experiences of 14 national-level middle school biology competition winners, proposed a three-stage cultivation model—"interest enlightenment—foundation consolidation and knowledge expansion—weakness remediation and skill strengthening"—providing direct practical support for tiered integration of competition content with conventional teaching. The author has devoted many years to frontline secondary school biology teaching and has independently established a systematic training framework for biology competitions, encompassing selection, curriculum design, experimental training, and psychological guidance. Under this system, students have achieved one national-level gold medal (with the student selected for the national training team and admitted to Peking University), one silver medal, 16 first prizes in the National Biology League, nearly 40 second and third prizes, 14 students admitted to Tsinghua University and Peking University, three students achieving top-25 scores in the Guangdong Gaokao (masked), and over a hundred students admitted to C9 universities, the National University of Defense Technology, and Sun Yat-sen University. Based on this practical experience, this study focuses on the integration pathways of biology competition content with conventional classroom teaching. It aims to provide practical solutions for addressing the pain points of conventional teaching, improving the quality of biology instruction, and offering empirical support for research on curriculum and teaching in basic education.

This study employs literature review, action research, and case analysis methods, integrating years of teaching practice data, key literature insights, and relevant international research findings to systematically examine the feasibility and effectiveness of integration. The paper is structured as follows: the first section presents the theoretical foundations of integration; the second section analyzes its multifaceted educational value; the third section proposes specific practical pathways; the fourth section validates the integration model through teaching cases; and the final section discusses challenges and prospects, providing reference for the reform of secondary school biology teaching.

2. Theoretical foundations for integrating biology competition content with conventional classroom teaching

2.1. Synergistic support of constructivism and STS educational thought

Constructivism posits that learning is a process in which students actively construct the meaning of knowledge rather than passively receiving information. The STS (Science, Technology, Society) educational framework proposed by Jianjun Li and Zeyong Zhang [4] emphasizes the organic integration of science and technology with society. Through problem-driven and practice-oriented inquiry, STS education cultivates students' sense of participation and problem-solving abilities. Its content encompasses the social context of science and technology, the application of knowledge, logical reasoning, and value cultivation, closely aligning with the constructivist principle of "active participation and meaning construction". Research by Sadler et al. [6] across 12 countries also confirms that integrating STS education with conventional classrooms can significantly enhance students' ability to apply knowledge.

Biology competitions emphasize guiding students to explore knowledge independently through experimental inquiry, problem-solving, and logical reasoning, which aligns perfectly with the practice-oriented focus of STS education. For example, deep exploration of genetic mapping and cell division mechanisms in competitions requires students to construct logical frameworks and validate hypotheses based on their existing knowledge. Incorporating this STS-inspired inquiry model into conventional classrooms can break the traditional "teacher lecture–student memorization" pattern, allowing students to understand the essence of knowledge through independent investigation and develop a structured knowledge system.

2.2. Teaching reform requirements oriented toward core competencies

At the secondary school level, core competencies in biology include four dimensions: life concepts, scientific thinking, scientific inquiry, and social responsibility. In the *Teacher's Guide to the Senior High School Biology Curriculum Standards*, Yuanyi Ding et al. [1] emphasize that cultivating core competencies requires diverse teaching content and practical activities, as mere knowledge transmission is insufficient to develop competencies. Research by Jianjun Li and Zeyong Zhang [4] further demonstrates that biology competitions, as an important vehicle for quality-oriented education, structure their content around core competencies: exploring ecosystem stability to cultivate life concepts, designing experiments and analyzing data to train scientific thinking, and completing competition projects collaboratively to strengthen social responsibility. This aligns closely with the goals of core competency cultivation in China.

Internationally, the "5E instructional model" proposed by Bybee [7] also emphasizes inquiry-based learning to develop students' scientific literacy, echoing both STS educational principles and China's core competency objectives. The integration of these approaches facilitates the organic unification of "knowledge transmission" and "competency cultivation," effectively advancing educational reform.

2.3. Alignment with the Zone of Proximal Development and the three-stage cultivation model

Vygotsky's theory of the Zone of Proximal Development (ZPD) asserts that teaching should focus on students' "potential developmental level", promoting progress from the "current level" to the "potential level" through appropriate instructional support. The three-stage cultivation model proposed by Chen, Cai, and Nie [5] —"interest enlightenment—foundation consolidation and knowledge expansion—weakness remediation and skill strengthening"—corresponds closely with this theory. The "interest enlightenment" stage nurtures students' curiosity, catering to the cognitive needs of students at the foundational level; the "foundation consolidation and knowledge expansion" stage constructs a structured knowledge system, supporting the developmental needs of intermediate-level students; and the "weakness remediation and skill strengthening" stage addresses competency bottlenecks, meeting the advanced needs of high-achieving students. Research by Wu et al. on high schools in China and Singapore also shows that tiered integration based on the ZPD effectively meets the learning needs of students at different levels [8].

Conventional classroom teaching must address all students, with content difficulty generally set at the intermediate level, making it difficult to satisfy the developmental needs of advanced learners. Biology competition content, by contrast, extends and deepens textbook knowledge—for example, expanding the conventional classroom topic of "gene expression" to the competition-level topic of "regulatory mechanisms of gene expression in prokaryotes and eukaryotes". This content sits precisely within the ZPD of advanced learners. Jianjun Li and Zeyong Zhang also note that competition content can be tiered through "foundation expansion—deep inquiry" designs to accommodate different learning situations, consistent with the three-stage cultivation model's stratified approach and supporting personalized development [4].

3. Educational value of integrating biology competition content with conventional classroom teaching

3.1. Promoting students' comprehensive development

3.1.1. Stimulating learning interest and establishing an enlightened foundation

Biology competition content is closely related to real-life contexts and combines both interest and challenge. Chen, Cai, Nie, and colleagues [5] emphasize in the three-stage cultivation model that "interest enlightenment" is the primary driving force in nurturing top-performing students. Engaging experiments such as "painting with fluorescent bacteria" or "leaf vein detective rubbings" stimulate inquiry desire through visual impact and embodied cognition. Jianjun Li and Zeyong Zhang [4] also note that competition topics such as "microbial fermentation technology" and "biodiversity surveys" allow students to directly perceive the social value of biology. Research by Yaoting Xiao et al. indicates that integrating such competition-based, interest-driven content into classrooms can increase the proportion of students who actively ask questions and engage in collaborative inquiry by more than 50% [9]. In practice, classrooms incorporating competition content show student engagement rates exceeding 60%, with significant enhancement in learning interest and initiative, consistent with the "interest-driven learning" phenomenon observed in STEAM teaching [10] by Jacobs et al.

3.1.2. Consolidating knowledge foundations and enhancing inquiry abilities

The "foundation consolidation and knowledge expansion" stage proposed by Chen, Cai, and Nie [5] emphasizes constructing a structured knowledge network through a three-tiered curriculum system: foundational courses, extended courses, and frontier courses. Biology competitions extend textbook knowledge in depth—for example, expanding "laws of inheritance" to "polygenic inheritance" and "population genetics"—allowing students to form comprehensive knowledge frameworks. Simultaneously, competitions emphasize logical reasoning and experimental design, which can be reinforced through tasks such as "mantis shrimp dissection" or "fruit wine production", and these skills are transferable to conventional classroom learning. Wang Diankai et al., through analysis of national biology competition experimental problems, reached similar conclusions [11], while international research by Ozdemir et al. [12] confirms that IBO preparation can improve students' scientific thinking test scores by 18%. Among the author's students, those participating in integrated teaching exhibited a 45% higher award rate in the National Biology League than non-participating students, and their scientific thinking skills were well reflected in the Gaokao examinations.

3.1.3. Strengthening weaknesses and supporting academic advancement

The "weakness remediation and skill strengthening" stage highlighted by Chen, Cai, and Nie [5] emphasizes identifying cognitive blind spots and reinforcing experimental skills to overcome competency bottlenecks. The in-depth expansion of textbook knowledge in competition content supports pathways such as the Strong Foundation Plan and comprehensive evaluation for further education. Qimao Sun also notes that competition training contributes to students' academic advancement [13]. Internationally, IBO preparation has become an important reference in university selection for innovative talent. Research by Ozdemir et al. [12] shows that students participating in integrated competition teaching had a more than 30% higher success rate in independent university admissions. Among the author's students, 14 were admitted to Tsinghua University and Peking University, and three achieved top-25 scores in the Guangdong Gaokao, all closely associated with the model of integrating competition content into conventional teaching.

3.2. Supporting teacher professional development

Integrated teaching requires teachers to master not only conventional curriculum frameworks and instructional methods but also the knowledge architecture and cultivation logic of competition content. Research by Chen, Cai, and Nie [5] shows that competition training demands teachers possess multifaceted abilities including curriculum design, error diagnosis, and experimental guidance, which in turn drives the enhancement of their knowledge base and instructional skills. Jianjun Li and Zeyong Zhang [4] also point out that competition coaching requires teachers to integrate interdisciplinary knowledge and innovate teaching methods, significantly improving curriculum design and cross-disciplinary integration abilities. International research by Sadler et al. [6] confirms that teachers involved in interdisciplinary integrated teaching experience more substantial professional growth. In practice, teachers continuously enhance their professional competence through selecting competition content, designing integrated teaching plans, and optimizing instructional methods. Moreover, the educational commitment developed during competition coaching provides a sustainable source of motivation [14], while collaboration with university experts and peers further expands professional development opportunities.

3.3. Enhancing curriculum system construction

Integrating biology competition content with conventional classroom teaching enriches instructional content and optimizes curriculum structure. The three-tiered curriculum system proposed by Chen, Cai, and Nie [5] (foundational courses + extended courses + frontier courses) provides direct guidance for integrated curriculum construction: foundational courses, centered on the textbook, ensure mastery of core knowledge; extended courses incorporate competition-based foundational expansion content (e.g., STS case studies of technology applications), meeting the developmental needs of most students; and inquiry-based courses select competition inquiry topics (e.g., ecosystem surveys, genetic disease analysis) for advanced students to explore in depth. Jianjun Li and Zeyong Zhang [4] also emphasize that competition content selection should follow the principles of "textbook alignment, social relevance, and practical feasibility", consistent with the logic of constructing a three-tiered curriculum. STEAM teaching practices by Jacobs et al. [10] further demonstrate that this curriculum structure achieves an organic balance between "broad coverage and advanced development," providing a practical model for secondary school biology curriculum reform.

4. Practical pathways for integrating biology competition content with conventional classroom teaching

4.1. Curriculum content reconstruction: three-stage stratification to match student profiles

4.1.1. Content selection principles

Integrated teaching should follow the principles proposed by Jianjun Li and Zeyong Zhang [4]—"textbook alignment, social relevance, and practical feasibility"—while also referencing the three-stage cultivation logic of Chen, Cai, and Nie [5]. Priority should be given to competition content that is highly relevant to textbook knowledge and adaptable to different cognitive stages. For example, in the "enlightenment stage", engaging experiments such as "painting with fluorescent bacteria" and "awakening seeds" are selected; in the "foundation consolidation stage", foundational extension topics such as "dominant/recessive trait judgment methods" and "analysis of meiotic abnormalities" are incorporated; in the "skill strengthening stage", competition challenges such as "in-depth analysis of genetic maps" and "experimental protocol optimization" are introduced.

4.1.2. Stratified design strategies

Drawing on the three-stage model of Chen, Cai, and Nie [5] , the integrated content is divided into three layers: Basic Layer (Interest Enlightenment): Mandatory for all students, focusing on engaging experiments and core knowledge points (e.g., the "cell membrane bubble factory" experiment) to stimulate interest. Intermediate Layer (Foundation Consolidation and Knowledge Expansion): Selected by most students, covering extended knowledge points in competitions (e.g., "fundamentals of polygenic inheritance"), implemented through homework, group discussions, and in-class exercises. Advanced Layer (Weakness Remediation and Skill Strengthening): Targeted at a few students for in-depth study of competition inquiry topics (e.g., "optimization of fruit wine production experiments" or "foraging strategies of the greater false vampire bat"), implemented via school-based courses or interest groups. The *National Middle School Biology League and Competition Regulations (Draft)* also emphasizes that competition activities should balance accessibility and advancement. Research by Wu et al. [8] confirms that stratified design enhances the effectiveness of integrated teaching.

4.2. Innovative teaching methods: inquiry-oriented and multi-dimensional integration

4.2.1. Engaging experiments for interest enlightenment

Based on the "interest enlightenment" stage of Chen, Cai, and Nie [5], competition-based engaging experiments are introduced in conventional classrooms to stimulate interest through embodied cognition. For example, in the "painting with fluorescent bacteria" experiment, students' curiosity is triggered by observing the fluorescence of engineered bacteria under UV light. In the "leaf vein detective rubbing" experiment, hands-on activities help students intuitively understand the function of leaf veins. These experiments are simple to operate and highly engaging, quickly capturing students' attention and laying the foundation for subsequent integrated teaching.

4.2.2. Three-tiered curriculum teaching approach

Drawing on the pyramid curriculum system of Chen, Cai, and Nie [5], an integrated teaching curriculum is constructed: Foundational Courses: Based on textbooks, establishing a core knowledge framework. Extended Courses: Combining competition content and external resources, such as inviting university experts for specialized lectures or organizing laboratory visits. Frontier Courses: Introducing college-level preparatory content (e.g., fundamentals of molecular biology) and research literature analysis to challenge students' cognitive limits. Jianjun Li and Zeyong Zhang [4] also note that fieldwork and group inquiry from competition coaching can be integrated into extended courses to strengthen practical skills.

4.2.3. Error diagnosis and personalized guidance

Referring to the "weakness remediation and skill strengthening" stage of Chen, Cai, and Nie [5], students' knowledge gaps and skill weaknesses are precisely identified through competition problem exercises and analysis of daily assignments. For instance, students weak in genetic calculations are given targeted exercises, and those with insufficient experimental design skills are provided with competition case studies accompanied by hands-on practice. AI tools can assist in diagnosis through interactive question-and-answer sessions to clarify misconceptions. Combined with the "one-on-one tutoring + small-group peer support" model proposed by Xiaomin Jiang [15], this approach ensures that each student receives personalized guidance tailored to their specific needs.

4.3. Evaluation system optimization: process-oriented and multi-dimensional

4.3.1. Three-stage formative evaluation

Aligned with the three-stage cultivation model, a corresponding evaluation system is established: in the enlightenment stage, students are assessed on experimental participation and interest stimulation; in the foundation consolidation stage, evaluation focuses on the completeness of the knowledge system and the development of scientific thinking; in the skill strengthening stage, assessment emphasizes proficiency in experimental skills and the quality of inquiry project completion. Research by Xuefu Zhong also indicates that formative evaluation provides a more comprehensive reflection of student learning outcomes [16].

4.3.2. Multi-dimensional evaluation indicators

Evaluation indicators cover dimensions emphasized by Jianjun Li and Zeyong Zhang [4]—scientific thinking, inquiry ability, teamwork, and social responsibility—as well as those highlighted by Chen, Cai, and Nie [5]—knowledge structure, experimental skills, and error correction. For example, in the integrated teaching of "laws of inheritance", assessment includes both mastery of knowledge and logical reasoning in genetic map analysis; in the "ecosystem survey" project, evaluation considers both data accuracy and the feasibility of proposed conservation recommendations.

4.3.3. Student self-assessment and peer assessment

Students are encouraged to participate in self-assessment and peer evaluation. Drawing on the "group collaborative inquiry" evaluation model of Li and Zhang and the "experimental results exchange" mechanism of Chen, Cai, and Nie [5], students reflect on their learning processes through self-assessment and learn experimental design techniques and data analysis methods from peers through mutual evaluation. Research by Biying Chen confirms that student participation in evaluation significantly enhances learning initiative and reflective ability [17].

4.4. Teaching resource integration: internal-external coordination and collaborative sharing

4.4.1. Internal school resource integration

School resources such as laboratories, libraries, and multimedia classrooms are systematically integrated to establish a repository for integrated teaching resources, including competition problems, engaging experiment protocols (e.g., the "painting with fluorescent bacteria" procedure), and error case studies. A collaborative team of biology instructors and competition coaches is formed to facilitate knowledge sharing and experience exchange. Jianjun Li and Zeyong Zhang also emphasize that systematic integration of internal school resources is fundamental for the effective fusion of competitions and classroom teaching.

4.4.2. External resource expansion

Following the "extended courses" design concept of Chen, Cai, and Nie [5], cooperation with universities and research institutions is strengthened. Experts are invited to give specialized lectures and supervise small research projects. Students participate in fieldwork and visit biological museums to broaden their horizons. College textbooks, research papers, and other resources are introduced to support frontier courses. Research by Jianqiu Liu et al. also demonstrates that expanding external resources can significantly enhance both the depth and breadth of competition-based teaching [18].

5. Case analysis of practical implementation

Using the author's school as an example, the integration of biology competition content with conventional classroom teaching was piloted in the second-year (Grade 11) biology curriculum, with the Genetics module selected as the experimental focus. The specific implementation is as follows:

5.1. Design of integrated content

Following the three-stage cultivation model: Basic Layer (Enlightenment): The "awakening seeds" experiment was used to stimulate student interest, incorporating foundational content such as "dominant/recessive trait judgment methods". Intermediate Layer (Foundation Consolidation): Extended content included "applications of multiple allele free combination" and "exceptions in sex-linked inheritance", constructing a structured genetic knowledge system. Advanced Layer (Skill Strengthening): An inquiry project on "human genetic disease investigation and genetic counseling" was designed to reinforce experimental design and data analysis skills.

5.2. Teaching implementation process

In the enlightenment stage, students conducted the "awakening seeds" experiment to observe the effect of gibberellin on mung bean germination. During the foundation consolidation stage, the "three-tiered curriculum teaching method" was applied: foundational courses covered core textbook knowledge; extended courses analyzed competition case studies on genetics; and frontier courses introduced "foundations of population genetics". In the skill strengthening stage, student weaknesses (e.g., genetic map analysis) were identified through error diagnosis, targeted exercises were designed, and AI-assisted Q&A tools were used to support learning. A genetics interest group was formed, and students conducted inquiry projects during after-school sessions, with teachers providing regular individualized guidance.

5.3. Implementation outcomes

After one semester of integrated teaching, student performance improved significantly: The class's average biology score increased by 15% compared to classes not using integrated teaching. Two students won first prizes and five students won second prizes in the National Biology League. Three students were admitted to Tsinghua University and Peking University through the Strong Foundation Plan. The class's average Gaokao biology score ranked among the top in the province, with three students entering Tsinghua and Peking University. These results confirm the observations of Chen, Cai, and Nie [5] that the three-stage model enhances both competition and academic performance, align with Jianjun Li and Zeyong Zhang's conclusion [4] that competition integration with STS education improves overall competence, and are consistent with the international phenomena [12] observed by Ozdemir et al.

5.4. Challenges and solutions

Key challenges encountered during implementation included limited class hours, which restricted the full development of extended content, and some students struggling to keep up due to weak foundational knowledge. Solutions included: Using school-based courses and after-school sessions to supplement instructional time [19]. Following the "stratified guidance" approach of Chen, Cai, and Nie [5], individualized plans were designed for students with weaker foundations, supported through one-on-one tutoring and small-group peer assistance. Optimizing the design of integrated content to balance core knowledge points with extended competition material.

6. Discussion and prospects

6.1. Challenges in integrated teaching

Although the integration of biology competition content with conventional classroom teaching has achieved notable results, several challenges remain: Limited instructional time: Scarce class hours make it difficult to fully implement inquiry-based learning. Increased teacher workload: Teachers are required to master both conventional teaching and competition coaching. Chen, Cai, and Nie [5] also note that competition-based training demands high-level skills in curriculum design and error diagnosis. Evaluation system limitations: Multi-dimensional assessments are difficult to implement on a large scale. Regional and school resource disparities: Some schools lack laboratory facilities or fieldwork sites, limiting their ability to conduct engaging experiments and inquiry-based projects.

6.2. Strategies for addressing challenges

To address these challenges, the following strategies are proposed: Optimize curriculum design: Increase school-based courses and after-school sessions to provide sufficient time for implementing the three-stage model. Strengthen teacher training: Enhance teachers' competence in integrated teaching and competition coaching through specialized lectures and professional exchanges, drawing on Chen, Cai, and Nie's [5] experience in cultivating multi-dimensional teacher capabilities. Promote evaluation system reform: Leverage information technology to develop intelligent evaluation platforms. Coordinate regional resources: Reduce disparities among schools through resource sharing and teacher mobility, providing standardized experimental protocols and teaching cases for resource-constrained schools.

6.3. Future prospects

Looking ahead, integrated teaching should advance toward "deep integration, intelligent integration, and broad dissemination": Depth of integration: Further align the three-stage model with STS and STEAM principles, shifting from "knowledge integration" to "competency integration". Integration methods: Use AI and other information technologies to optimize error diagnosis and personalized guidance, following international trends in "intelligent competition-based teaching." Scope of dissemination: Summarize successful integrated teaching practices and promote standardized three-stage integration programs to more schools, especially supporting those with limited resources. Chen, Cai, and Nie [5] also foresee that, with ongoing technological iteration, a human–machine collaborative model for competition-based training will provide a practical paradigm for cultivating top-tier talent in basic education.

7. Conclusion

The integration of biology competition content with conventional classroom teaching represents an effective pathway for reforming secondary school biology instruction under the dual context of the "Double Reduction" policy and core competency-oriented education. This integration model is grounded in constructivist learning theory, the STS education framework proposed by Jianjun Li and colleagues [4], the three-stage cultivation model developed by Chen, Cai, and Nie [5], STEAM education principles, core competency objectives, and Vygotsky's zone of proximal development. Drawing on international biology competition practices, it achieves complementary advantages between competition-based and conventional instruction through curriculum content reconstruction, innovative teaching methods, optimized evaluation systems, and integrated teaching resources. Practical application shows that integrated teaching not only stimulates students' interest in biology, enhances scientific thinking and inquiry skills, and supports academic advancement, but also promotes teacher professional growth and improves curriculum system design. These effects are validated by both domestic and international empirical data.

Although challenges remain—such as limited instructional time and increased teacher workload—these issues can be gradually addressed through strategies such as curriculum optimization, enhanced teacher training, and evaluation system reform. Looking ahead, with continued education reform, the application of information technology, and localized implementation of international educational concepts, the integration of biology competition content with conventional classroom teaching will become deeper, smarter, and more widely implemented, providing strong support for cultivating innovative talent with core competencies.

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