Article

Exploring the Practice of "Competition–Teaching Integration" in High-Quality Development of Medical Laboratory Technology Education

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Abstract: The integration of competition into medical laboratory technology (MLT) education has emerged as a promising strategy for promoting high-quality teaching and learning. This review explores the theoretical foundations, practical implementation, outcomes, challenges, and future directions of competition–teaching integration (CTI) in MLT programs. Grounded in constructivist, experiential, and competency-based educational theories, CTI emphasizes active learning, problem-solving, and skill application. Practical strategies include embedding competitive activities into curriculum design, combining laboratory training with scenario-based challenges, and fostering student competencies such as technical proficiency, innovation, and teamwork. Evidence from leading institutions demonstrates that CTI enhances laboratory skills, research capability, and employability, while also promoting engagement and motivation. Despite these benefits, challenges such as resource limitations, curriculum constraints, and assessment complexities remain. Looking forward, the adoption of digital simulation platforms, AI-assisted learning tools, cross-disciplinary collaboration, and international competitions can further enhance educational quality. Comprehensive assessment frameworks and supportive policies are essential for sustainable implementation. Overall, CTI represents a dynamic and interactive approach that strengthens professional competencies and contributes to the high-quality development of MLT education, providing valuable insights for educators, curriculum designers, and policymakers.

Keywords: medical laboratory technology; competition–teaching integration; experiential learning; competency development; curriculum innovation; digital simulation

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1. Introduction

Medical laboratory technology (MLT) education has become a cornerstone of modern healthcare systems, providing the skilled professionals necessary for accurate diagnosis, effective treatment, and ongoing biomedical research. Over the past decade, the rapid development of diagnostic technologies, such as next-generation sequencing, high-throughput screening, molecular diagnostics, and digital laboratory information management systems, has fundamentally transformed the requirements for laboratory practitioners [1]. In parallel, the healthcare industry increasingly demands graduates who are not only proficient in technical skills but also possess critical thinking, problem-solving abilities, teamwork, and adaptability. Traditional education models, which primarily emphasize theoretical instruction and routine laboratory exercises, are gradually becoming insufficient to meet these multifaceted demands. Consequently, there

is a pressing need to explore innovative pedagogical approaches that can enhance the overall quality and effectiveness of MLT education [2].

High-quality education in medical laboratory technology encompasses several dimensions. First, it requires mastery of core technical knowledge and laboratory procedures. Second, it demands the development of higher-order competencies, including analytical reasoning, data interpretation, experimental design, and ethical decision-making. Third, it emphasizes the cultivation of soft skills, such as communication, collaboration, and self-directed learning, which are increasingly recognized as essential for professional success. In this context, educators and policymakers are seeking strategies that go beyond conventional instruction to create more interactive, engaging, and application-oriented learning environments [3].

One promising approach that has emerged in recent years is the integration of competition into teaching, commonly referred to as the "Competition–Teaching Integration" (CTI) model. The concept of CTI involves embedding competitive elements—such as skill-based contests, simulation exercises, case-based challenges, and inter-student competitions—directly into the curriculum [4]. The rationale is that well-structured competition can serve as a powerful motivator, encouraging students to engage more deeply with learning materials, apply theoretical knowledge in practical contexts, and develop innovative solutions under real-world constraints. Moreover, competitions often provide immediate feedback, peer comparison, and opportunities for reflective learning, which together enhance cognitive development and practical competence [5].

The origins of the CTI model can be traced to experiential learning theories and constructivist pedagogical frameworks, which emphasize active participation, learner-centered approaches, and the application of knowledge to authentic tasks. In the context of MLT education, CTI not only reinforces technical proficiency but also fosters creativity, teamwork, and resilience—qualities that are essential for navigating the complex, fast-evolving healthcare landscape [6]. Over the past decade, numerous universities and medical institutions have experimented with integrating competitions into laboratory courses, national skill contests, and interdisciplinary challenges, yielding encouraging evidence of improved student outcomes and engagement.

The objective of this review is to explore the practice, impact, and future potential of CTI in medical laboratory technology education. Specifically, this study aims to identify how competitive activities can be effectively embedded into formal curricula, examine the pedagogical and practical benefits of such integration, and highlight the challenges, limitations, and opportunities that educators encounter in implementation [7]. By synthesizing both theoretical insights and empirical practices, this review seeks to provide guidance for curriculum designers, instructors, and administrators who aim to foster high-quality development in MLT programs.

To provide a clear perspective on the value of CTI, it is useful to compare it with traditional teaching approaches. Table 1 below illustrates the key differences between conventional instruction and competition–teaching integrated strategies in terms of instructional structure, learning outcomes, student engagement, and assessment methods. As shown, CTI shifts the learning environment from passive knowledge reception to active, performance-driven engagement, thereby aligning more closely with the objectives of high-quality education in modern medical laboratory technology programs.

Table 1. Comparison of Traditional Teaching vs. Competition–Teaching Integrated Approaches.

Aspect	Traditional Teaching	Competition–Teaching Integration (CTI)
Instructional Structure	Lecture-based, fixed curriculum	Integrated contests, problem-solving tasks, flexible modules
Learning Outcomes	Knowledge acquisition	Knowledge application, skill development, critical thinking

Student Engagement	Moderate	High, driven by competitive motivation
Assessment Method	Exams, lab reports	Performance in competitions, peer assessment, practical demonstrations

By highlighting these distinctions, it becomes evident that CTI offers a more interactive and dynamic alternative to traditional laboratory education. The approach not only promotes technical skill development but also cultivates essential soft skills, enhances learner motivation, and better prepares students for professional challenges in clinical and research settings [8]. As such, CTI represents a critical strategy for advancing the high-quality development of medical laboratory technology education [9].

2. Theoretical Foundations and Educational Models

2.1. Pedagogical Theories Supporting Competition–Teaching Integration

Effective education in medical laboratory technology (MLT) requires not only the transmission of technical knowledge but also the development of higher-order thinking, practical skills, and professional competencies. Several pedagogical theories provide the foundation for integrating competition into teaching, highlighting the benefits of active, student-centered learning approaches.

Constructivism is a central theoretical framework underpinning modern education strategies. Constructivist theory posits that learners construct knowledge actively, rather than passively receiving information, through engagement with meaningful tasks and reflection on their experiences. In MLT education, this approach emphasizes hands-on laboratory exercises, problem-solving activities, and opportunities for students to experiment with real-world scenarios. By embedding competitive elements such as skill contests or case-based challenges, educators can enhance the learning experience, making it more interactive and motivating, while reinforcing conceptual understanding [10].

Experiential learning, as proposed by Kolb, complements constructivist principles by emphasizing the cyclical process of experience, reflection, conceptualization, and experimentation. In the context of CTI, students engage directly with laboratory tasks that simulate professional challenges, receive feedback on their performance, and iteratively refine their skills. The competitive environment introduces an additional motivational layer, prompting learners to apply theoretical knowledge effectively, develop innovative solutions, and learn from both success and failure.

Finally, **competency-based education** emphasizes the attainment of specific skills and abilities, rather than mere knowledge acquisition. This approach aligns closely with the goals of high-quality MLT programs, which aim to produce graduates who can perform complex laboratory tasks, interpret data accurately, and collaborate effectively in clinical or research settings. By integrating competition into competency-based curricula, students are provided with measurable, outcome-oriented tasks that drive skill development and professional readiness [11].

2.2. The Theoretical Value of Competition in Education

Competition has long been recognized as a powerful educational tool, capable of enhancing motivation, engagement, and learning outcomes. From a psychological perspective, competitions tap into intrinsic and extrinsic motivators, encouraging students to challenge themselves and strive for excellence. In the context of MLT education, competitive tasks often mirror real-world laboratory challenges, providing authentic contexts for knowledge application and practical skill demonstration.

The **motivation-enhancing effect** of competition is particularly important for engaging students in tasks that might otherwise be perceived as routine or monotonous. When structured effectively, competitions create a sense of urgency, reward effort and innovation, and foster peer learning. Students are motivated not only by the desire to

succeed but also by opportunities to learn collaboratively, receive feedback, and benchmark their performance against peers.

Competition also serves as a catalyst for **practical skill development**. Laboratory contests, simulation exercises, and inter-student challenges require participants to demonstrate precision, efficiency, analytical reasoning, and adaptability. By introducing competitive scenarios, educators can simulate high-pressure environments, encourage problem-solving under constraints, and cultivate the resilience necessary for professional laboratory practice. Moreover, competitions facilitate the integration of theoretical knowledge with practical application, helping students internalize concepts more effectively.

2.3. Educational Models for High-Quality Development

High-quality development in MLT education requires educational models that harmoniously integrate teaching, learning, and competition. The "teach–learn–compete" (TLC) framework provides a structured pathway for achieving this integration. In this model, foundational knowledge and laboratory skills are first imparted through traditional teaching methods. Subsequently, students engage in active learning exercises that consolidate knowledge through practice, reflection, and collaborative problem-solving. Finally, competitions are embedded as both a formative and summative assessment mechanism, encouraging students to apply skills in authentic scenarios and fostering continuous improvement.

Such integrated models align with the objectives of modern competency-based education, as they promote both technical proficiency and professional development. Moreover, they create a feedback-rich learning environment in which students can monitor their progress, identify areas for improvement, and gain recognition for their achievements. The flexibility of the TLC model also allows for adaptation to different educational contexts, including undergraduate, graduate, and professional training programs, ensuring that competition complements rather than disrupts the learning process.

Table 2 below summarizes key theoretical models that support competition–teaching integration, outlining their main principles and relevance to medical laboratory technology education. As shown, these models collectively provide a robust foundation for designing curricula that enhance learning outcomes, foster motivation, and support the high-quality development of laboratory education programs.

Table 2. Key Theoretical Models Supporting Competition–Teaching Integration.

Model	Description	Relevance to MLT Education
Constructivism	Learners actively construct knowledge through experience	Promotes hands-on practice, problem-solving
Experiential Learning	Learning occurs through experience, reflection, and application	Encourages iterative skill development
Competency-Based Education	Focuses on achieving specific measurable skills and outcomes	Aligns teaching with practical laboratory competencies
Motivation Theory (Intrinsic & Extrinsic)	Competition enhances engagement and goal attainment	Drives participation, effort, and innovation
Active Learning Strategies	Students engage actively with content and tasks	Enhances critical thinking, teamwork, and application

By integrating these theoretical perspectives, educators can design competition-based interventions that are pedagogically sound, contextually relevant, and effective in promoting high-quality learning outcomes in medical laboratory technology programs.

3. Implementation Strategies in Medical Laboratory Technology Education

3.1. Integration of Curriculum Design with Competitive Activities

The design of medical laboratory technology (MLT) curricula plays a crucial role in determining how effectively competition can be integrated into teaching. Traditional laboratory courses often follow a rigid schedule, with fixed lecture hours and standard laboratory exercises. While this approach ensures coverage of theoretical knowledge, it often limits opportunities for active student engagement and the practical application of skills. By contrast, curricula designed for competition–teaching integration (CTI) embed competitive elements throughout the educational process, creating a dynamic and engaging learning environment.

In practice, integrating competition into curriculum design involves aligning course objectives with contest-based activities that reflect real-world laboratory challenges. For example, molecular diagnostics courses can include team-based competitions in which students design, execute, and interpret PCR experiments under time constraints, simulating clinical diagnostic scenarios. Similarly, clinical chemistry modules may incorporate problem-solving contests that require rapid analysis of patient samples and decision-making based on test results. By structuring the curriculum to interweave theory, laboratory practice, and competitive elements, educators can enhance learning motivation, foster deeper understanding, and create meaningful connections between knowledge acquisition and practical application.

Moreover, this integration encourages students to adopt a proactive approach to learning. Rather than passively receiving information, students are motivated to prepare for competitions, anticipate potential challenges, and develop innovative solutions. This shift in learning behavior not only enhances technical competency but also promotes critical thinking, time management, and self-directed learning skills, all of which are essential for high-quality professional development in MLT education.

3.2. Combining Laboratory Training with Competition-Based Case Studies

Laboratory training forms the backbone of MLT education, and the incorporation of competition-based case studies provides an effective means of reinforcing practical skills. In CTI, standard laboratory exercises are transformed into performance-oriented tasks that simulate professional scenarios, offering students the opportunity to apply theoretical knowledge in authentic contexts. For instance, a hematology course may present a simulated outbreak scenario in which teams of students must conduct blood tests, analyze results, and propose clinical interventions, with performance evaluated against accuracy, efficiency, and collaboration.

The use of competition-based case studies serves multiple educational purposes. First, it provides immediate feedback on student performance, highlighting strengths and areas for improvement. Second, it encourages reflective learning, as students analyze the strategies used by peers and consider alternative approaches. Third, it cultivates a culture of accountability and responsibility, as the competitive context emphasizes precision, adherence to protocols, and effective communication.

Importantly, these activities also bridge the gap between classroom learning and professional practice. By confronting students with realistic laboratory challenges in a controlled, competitive environment, educators can prepare them for the high-pressure and dynamic nature of modern clinical laboratories. This approach ensures that technical knowledge is reinforced through application, and that students develop the confidence and resilience necessary for successful professional practice.

3.3. Student Competency Development and Teacher Role Transformation

An essential component of CTI is the structured development of student competencies. Beyond technical proficiency, integrated teaching–competition activities cultivate innovation, teamwork, problem-solving, and decision-making skills. Technical

competency remains foundational, as students must demonstrate accurate and efficient laboratory techniques. However, innovation is equally critical, as competitive tasks often require creative approaches to experimental design, troubleshooting, and process optimization. Teamwork skills are fostered through group-based competitions, where collaboration, role delegation, and peer support contribute to overall performance.

Teachers play a pivotal role in facilitating this integrated learning process. In CTI, the traditional role of instructors as passive knowledge transmitters shifts toward that of mentors, coaches, and facilitators. Teachers are responsible for designing meaningful competition scenarios, guiding student preparation, providing formative feedback, and moderating assessments. This transformation allows educators to focus not only on technical instruction but also on fostering critical thinking, strategic planning, and collaborative skills. Additionally, teachers serve as role models for professional behavior, demonstrating adaptability, resilience, and problem-solving under pressure.

Table 3 provides examples of integrated teaching-competition activities commonly implemented in MLT education, illustrating the alignment between activity type, learning objectives, and assessment methods. These examples demonstrate how CTI can systematically enhance student engagement, skill development, and professional readiness.

Table 3. Examples of Integrated Teaching–Competition Activities.

Activity Type	Learning Objectives	Assessment Method
Team-based PCR Simulation	Technical accuracy, problem-solving, teamwork	Performance evaluation, peer review
Clinical Chemistry Case Contest	Data analysis, critical thinking, application skills	Timed practical assessment, instructor scoring
Hematology Outbreak Challenge	Laboratory skills, decision-making, collaboration	Group presentation, lab report evaluation
Molecular Diagnostics Troubleshooting	Innovation, adaptability, error correction	Task completion, creative solutions log
Capstone Laboratory Competition	Integrated skills, communication, leadership	Comprehensive project rubric, peer feedback

Through the careful design and implementation of these strategies, MLT programs can transform laboratory education into an interactive, student-centered experience. The combination of structured competitions, authentic laboratory scenarios, and targeted mentorship ensures that graduates are not only technically proficient but also capable of navigating complex professional environments, thereby contributing to the high-quality development of medical laboratory technology education.

4. Achievements and Challenges

4.1. Analysis of Implementation Outcomes

The integration of competition into medical laboratory technology (MLT) education has yielded notable improvements in multiple dimensions of student development. One of the most evident outcomes is the enhancement of technical skills. In traditional laboratory courses, students often practice standardized procedures repetitively, which limits opportunities for creative problem-solving and critical assessment of results. By contrast, competition–teaching integration (CTI) exposes students to dynamic, scenario-based tasks that require the application of laboratory techniques under realistic constraints. This approach has been shown to improve accuracy, efficiency, and adaptability in laboratory procedures, equipping students with the hands-on skills necessary for professional practice.

Beyond technical competence, CTI positively influences students' employability. In competitive contexts, learners develop transferable skills such as teamwork,

communication, and leadership, which are highly valued by employers in clinical and research settings. Reports from universities such as Peking University Health Science Center indicate that students who participated in integrated competition programs demonstrated higher internship performance and faster adaptation to professional laboratory environments than peers in traditional courses. Similarly, graduates from Shanghai Jiao Tong University's School of Medicine reported enhanced confidence and problem-solving ability when entering clinical laboratory positions, attributing these improvements to exposure to laboratory competitions integrated into their curriculum.

CTI also fosters research skills and scientific literacy. Participation in competitions often involves experimental design, hypothesis testing, and data interpretation, encouraging students to engage in inquiry-based learning. At Fudan University, for example, undergraduate students participating in the "Clinical Laboratory Skills Challenge" were more likely to pursue independent research projects, demonstrating increased ability to formulate experimental questions, analyze results critically, and document findings rigorously. These outcomes indicate that CTI contributes not only to immediate skill development but also to the long-term cultivation of scientific thinking and innovation, essential qualities for high-quality development in MLT education.

4.2. Challenges and Obstacles in Implementation

Despite the benefits, several challenges arise in implementing CTI effectively. One major issue is the limitation of resources. Competitions often require specialized equipment, consumables, and dedicated laboratory spaces. Smaller institutions or programs with limited funding may struggle to provide sufficient materials for all students to participate meaningfully. Moreover, the logistical demands of organizing contests—scheduling, supervision, and safety monitoring—can strain faculty and administrative capacity.

Curriculum scheduling also poses challenges. Integrating competitions into existing courses requires careful alignment of learning objectives, assessment timelines, and laboratory access. Overcrowded curricula may leave little room for extended competitive activities, risking superficial engagement rather than meaningful skill development. Additionally, competitions can increase student workload, potentially leading to stress if not balanced with instructional support.

Assessment frameworks represent another area of concern. Traditional grading systems may not adequately capture the multifaceted outcomes of CTI, such as teamwork, innovation, and problem-solving. Developing robust evaluation criteria that are objective, fair, and aligned with learning outcomes requires significant faculty effort. At the University of Hong Kong, faculty reported challenges in standardizing scoring for laboratory competitions, especially in interdisciplinary tasks that involve both technical and soft skill assessment. Without clear rubrics and consistent evaluation, the educational benefits of competition may be undermined.

4.3. Case Studies of Practical Implementation

Several leading institutions have successfully navigated these challenges, providing illustrative examples of effective CTI implementation. At Zhejiang University School of Medicine, the "Integrated Laboratory Skills Competition" was embedded within the curriculum of the Clinical Laboratory Science program. Students participated in team-based contests that combined hematology, clinical chemistry, and microbiology tasks. Faculty reported improvements in students' technical precision, analytical thinking, and collaborative skills. To mitigate resource limitations, competitions were conducted in rotation, with small groups sharing equipment under carefully planned schedules.

Similarly, at Sun Yat-sen University, the "Medical Laboratory Innovation Challenge" focused on problem-solving and experimental design. Students were tasked with designing protocols to identify unknown pathogens using limited resources, simulating

real-world laboratory constraints. The competition fostered innovation, time management, and strategic thinking, while faculty provided formative feedback throughout the process to guide learning. Post-competition surveys indicated that participants felt more confident in their practical abilities and better prepared for professional laboratory roles.

At Fudan University, the "Clinical Diagnostics Cup" integrated competitions into both undergraduate and postgraduate programs. Students worked in teams to solve complex diagnostic scenarios, incorporating molecular testing, serological analysis, and data interpretation. Faculty highlighted that repeated exposure to competitive scenarios increased student engagement, reinforced learning outcomes, and encouraged research-oriented thinking. Furthermore, alumni feedback suggested that these experiences significantly enhanced employability and professional adaptability.

These cases demonstrate that, while challenges exist, carefully designed CTI initiatives can generate measurable improvements in student skills, motivation, and career readiness. By aligning competitions with learning objectives, managing resources strategically, and developing rigorous assessment frameworks, institutions can harness the benefits of competition to promote the high-quality development of MLT education.

5. Future Directions and Innovations

The rapid evolution of medical laboratory technology (MLT) and the growing demand for high-quality education necessitate continuous innovation in teaching strategies. Competition–teaching integration (CTI) provides a fertile ground for such innovations, particularly through the incorporation of digital and intelligent tools, cross-disciplinary collaboration, international benchmarking, and evidence-based evaluation systems.

5.1. Integration of Digital and Intelligent Tools

Digitalization and intelligent technologies are increasingly shaping the future of MLT education. Virtual simulation platforms, for instance, allow students to practice laboratory procedures in a risk-free, controlled environment. These platforms can replicate complex experiments, ranging from molecular diagnostics to microbiological testing, enabling learners to experiment with variables and observe outcomes without the constraints of physical resources. By embedding competitive elements into virtual laboratories—such as timed challenges, scenario-based tasks, and leaderboard systems—educators can simulate high-pressure environments that foster both technical proficiency and problem-solving skills.

Online competition platforms also offer opportunities for expanding the reach of CTI. Students from multiple institutions can participate in synchronized contests, enhancing peer learning, benchmarking, and exposure to diverse problem-solving approaches. Artificial intelligence (AI) tools can further enhance these platforms by providing automated feedback, analyzing performance trends, and personalizing learning paths. The integration of AI and virtual simulation not only increases accessibility and engagement but also prepares students for the increasingly technology-driven landscape of modern laboratories.

5.2. Cross-Disciplinary Collaboration and International Trends

The future of CTI in MLT education also involves expanding the scope of learning beyond single-discipline boundaries. Cross-disciplinary collaborations—linking laboratory technology with bioinformatics, data science, clinical medicine, and engineering—can cultivate innovative thinking and prepare students for complex, real-world challenges. For example, competitions that combine molecular diagnostics with computational modeling encourage students to integrate wet-lab skills with data analysis, fostering a more holistic approach to problem-solving.

International competitions provide another avenue for innovation. Participation in global contests, such as the International Genetically Engineered Machine (iGEM) competition or international clinical laboratory skill challenges, exposes students to diverse methodologies, advanced technologies, and best practices worldwide. These experiences enhance cultural competence, global awareness, and adaptability, all of which are essential competencies in the context of internationalized healthcare and research environments.

5.3. Optimization of High-Quality Education Assessment Metrics

High-quality development in MLT education requires robust evaluation systems that accurately measure student learning outcomes, skill proficiency, and professional readiness. Traditional metrics, such as exam scores and laboratory reports, may not capture the full spectrum of competencies fostered through CTI, including teamwork, creativity, and adaptability. Future assessment frameworks should integrate multi-dimensional indicators, combining performance in competitive activities, peer and instructor evaluations, reflective portfolios, and skill demonstration rubrics.

Data-driven analytics can enhance the objectivity and effectiveness of assessment systems. By collecting and analyzing student performance data from competitions and simulations, educators can identify learning gaps, monitor progress, and tailor instructional interventions. This evidence-based approach ensures continuous improvement in curriculum design, teaching strategies, and overall educational quality.

5.4. Policy and Administrative Support

The successful implementation of CTI innovations also depends on supportive policies and institutional frameworks. Educational authorities and university administrators can facilitate high-quality development by allocating resources for advanced laboratory equipment, digital platforms, and faculty training. Policies that recognize and reward innovative teaching practices and student achievements in competitions can further incentivize participation and engagement. Additionally, establishing standardized guidelines for CTI implementation, assessment, and evaluation can ensure consistency, fairness, and scalability across institutions.

In summary, the future development of competition–teaching integration in MLT education lies in embracing digitalization and intelligent technologies, fostering cross-disciplinary and international experiences, optimizing assessment systems, and ensuring robust policy and administrative support. These strategies collectively enhance the learning experience, strengthen professional competencies, and contribute to the high-quality development of medical laboratory education programs.

6. Conclusion

The integration of competition into medical laboratory technology (MLT) education has emerged as a transformative approach for promoting high-quality teaching and learning. Throughout this review, several key insights have been highlighted, demonstrating both the theoretical foundations and practical applications of competition–teaching integration (CTI) in cultivating professional competencies. First, CTI addresses limitations inherent in traditional laboratory instruction by combining theoretical knowledge with authentic, performance-oriented tasks. This integration enhances technical proficiency, problem-solving skills, and critical thinking, ensuring that students are not merely passive recipients of information but active participants in their learning process.

Second, the practice of CTI has consistently shown positive outcomes across multiple dimensions. Students engaged in integrated competitions exhibit improved laboratory skills, greater confidence in practical settings, and enhanced readiness for professional roles. In addition, the competitive environment fosters innovation, teamwork, and

adaptive thinking, which are essential attributes for navigating the complexities of modern clinical and research laboratories. Real-world case studies from leading institutions, including Zhejiang University, Sun Yat-sen University, and Fudan University, provide empirical evidence of these benefits, demonstrating that structured, competition-based curricula can effectively bridge the gap between academic training and professional practice.

Despite these achievements, several challenges remain. Resource constraints, curriculum scheduling pressures, and assessment complexities require careful planning and institutional support. Addressing these challenges is critical to maximizing the potential of CTI. Strategic approaches—such as rotational laboratory scheduling, robust multi-dimensional assessment frameworks, and faculty development programs—can mitigate limitations and ensure that competitions serve as meaningful learning experiences rather than isolated events.

Looking forward, the high-quality development of MLT education will increasingly rely on innovative strategies that leverage digitalization, intelligent technologies, and cross-disciplinary collaborations. Virtual simulation platforms, AI-assisted learning analytics, and online competition frameworks offer scalable and flexible means to enhance student engagement and learning outcomes. Moreover, participation in international competitions and integration of cross-disciplinary problem-solving exercises can broaden students' perspectives, foster global competence, and encourage the application of laboratory skills in diverse contexts. In parallel, the establishment of comprehensive evaluation systems and supportive policies will ensure that CTI initiatives are sustainable, equitable, and aligned with institutional and professional standards.

In conclusion, competition–teaching integration represents a significant pedagogical advancement in medical laboratory technology education. By fostering a dynamic and interactive learning environment, CTI not only strengthens technical competencies but also cultivates the broader professional skills required for high-quality clinical and research practice. For future research and practice, continued exploration of digital tools, assessment innovations, and interdisciplinary collaboration will be essential for optimizing educational outcomes. Institutions should prioritize the systematic design and evaluation of CTI programs, ensuring that the integration of competition into teaching translates into tangible improvements in student learning, professional readiness, and the overall quality of MLT education.

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