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Integrating Clinical and Research Perspectives in Postgraduate Tumor Cell Biology Education: A "Small Class-Seminar" Model

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Abstract: Tumor Cell Biology, a burgeoning frontier in life sciences, is pivotal for equipping medical postgraduates with a robust knowledge system and skillset. This paper introduces an innovative "small class-seminar" teaching model that integrates clinical and research perspectives to enhance postgraduate training in Tumor Cell Biology. Utilizing an advanced information-based smart teaching platform and leveraging high-quality online educational resources, the model has been tailored to the educational needs of local medical colleges. The curriculum demonstrates significant success in fostering students' research design capabilities and innovative thinking. The model's effectiveness is underscored by its ability to cultivate multidisciplinary professionals ready to address the complex demands of the medical and health sectors in the new era.

1. Introduction

Graduate education, a cornerstone for nurturing high-level talent and fostering innovation, plays a pivotal role in enhancing a nation's innovation capabilities and global competitiveness. In the post-pandemic era, with the implementation of the "Healthy China" strategy, there is an urgent demand in the medical and health sectors for the cultivation of multidisciplinary professionals who are ethically and intellectually prepared to address the multifaceted societal needs. The necessity for such professionals is underscored by their requirement to not only possess comprehensive knowledge and skills but also exhibit robust teamwork, communication, perceptiveness, and innovation [1]. They must be adept at transforming practical challenges into research inquiries, equipped with the skills and innovative perspectives necessary to uncover disease patterns and devise new preventive and therapeutic strategies. However, the traditional large-scale lecture model in graduate education, which limits student autonomy, innovation, and problem-solving, falls short of meeting the evolving demands for highly skilled, adaptable professionals[2]. As a result, there is a pressing need to explore and implement innovative educational models that foster a more dynamic learning environment. These models should prioritize active learning methodologies, interdisciplinary collaboration, hands-on experience, and mentorship programs. By embracing such approaches, graduate programs can

better cultivate highly skilled, adaptable professionals who are well-prepared to drive innovation and address the multifaceted challenges in healthcare and beyond. This shift not only ensures the relevance and competitiveness of graduate education but also empowers future professionals to make meaningful contributions to public health and innovation on a global scale.

Tumor cell biology, a vibrant and swiftly advancing discipline within the life sciences, concentrates on the intrinsic nature, development, and progression of tumors [3]. Cancer is currently one of the deadliest diseases worldwide. Advances in high-throughput sequencing technologies have deepened our understanding of tumor etiology, metastasis, and progression [4]. Engaging medical graduate students in this domain is crucial for enhancing their grasp of cellular life processes and their integral roles in cancer diagnosis, treatment, prevention, and monitoring. From 2020 to 2023, our institution has spearheaded pedagogical reforms through the implementation of a “small class-seminar” teaching model. This model is distinguished by its emphasis on exploration and research to foster academic discourse, stimulate student creativity, and encourage the practical application of knowledge and problem-solving—a modern education philosophy that aligns with top global universities [5-7]. This innovative approach has garnered high praise from both faculty and students, establishing a robust foundation in tumor cell biology and offering novel insights and methodologies for the transformation of medical graduate education.

The integration of this innovative teaching model with the "Internet+" and "Medical+" interdisciplinary projects reflects our institution's commitment to a student-centric, inquiry-driven teaching method. This method not only enhances student engagement and creativity but also embodies the modern educational philosophy of "teacher-led, student-focused" learning [8]. The results from assessments and surveys indicate that this innovative teaching model has achieved significant success, providing valuable experiences for the cultivation of composite research talents in medical science in the new era.

2. Optimizing Curriculum Design

In the “small class-seminar” educational framework, educators transition from traditional “lecturers” to “facilitators”, employing diverse interactive methods to enhance intellectual engagement and ensure active student participation. This environment promotes in-depth discussions of each student’s questions and ideas, maintaining their central role in learning activities and fostering a dynamic academic atmosphere. Tumor cell biology, a rapidly evolving field, covers a broad range of topics. This course is tailored for graduate students embarking on oncology research during their postgraduate studies. However, due to diverse backgrounds and professional origins (e.g., nursing, pharmacy, agriculture, biotechnology), many of these students lack systematic education in medical cell biology, particularly in tumor cell biology, during their undergraduate years. Consequently, there exists a deficiency in structured training in research methodologies specific to oncological studies. To systematically structure the curriculum, we have developed three main instructional modules, “Solidifying Fundamentals”, “Case Study Applications”, and “Practical Research Design”. The “Solidifying Fundamentals” module utilizes Robert A. Weinberg’s “The Biology of Cancer” as the core textbook to explore tumor characteristics, including cellular and molecular bases, gene mutations, oncogenesis, oncogenes, and tumor suppressor genes, focusing on tumor cell properties. Discussions also cover tumor cell proliferation, genomic instability, mesenchymal transition, invasion, metastasis, and the tumor microenvironment and immunity, including the extracellular matrix and immunotherapeutic strategies. This course aims to deepen students’ understanding of tumor cell biology and molecular biology, build a strong theoretical base, and enhance their research skills.

The global incidence and mortality rates of malignant tumors have significantly increased over the past decades, making them a leading cause of death worldwide [9,10]. In this context, researchers and clinicians are key in the fight against cancer. Tumor cells constitute fundamental units for the study, comprehension, and management of tumors. A profound grasp of their intrinsic essence and

characteristics not only deepens our understanding of life's fundamental principles but also facilitates the more effective development of anti-tumor therapeutics. Our Case Study Applications module utilizes the expertise of seasoned researchers to enhance students' understanding and application of theory. Collaboratively, students delve into comprehensive literature reviews using databases such as PubMed, EBSCO, and Web of Science, exploring diverse topics including the intricate roles of proteins in tumor progression and the complex immune responses elicited by tumor cells.

They also design experimental protocols using tools like GEPIA, GEO, and TCGA to retrieve tumor data, design primers, prepare drug solutions, and construct gene expression vectors, thereby developing their problem-solving and practical skills. In current medical field, professionals must transform clinical problems into research topics and display innovative thinking, making research skill and awareness crucial in medical graduate education. Concurrently, students are organized into teams to devise experimental methodologies and strategies tailored to specific cases. This involves the utilization of tools such as GEPIA, GEO, and TCGA for retrieving tumor-related data, as well as tasks encompassing primer design, formulation of drug solutions, and the construction of gene overexpression and knockout vectors. These activities foster the development of problem-solving skills and practical proficiency, enabling students to internalize and apply foundational knowledge of tumor cell biology through practical engagement, thereby facilitating the synthesis of theoretical concepts with practical implementation. Through this instructional module, students progressively cultivate the capacity for critical analysis of academic topics within the realm of tumor cell biology and scientific inquiry. This pedagogical approach enhances their research literacy, preparing them to independently devise experiments, resolve intricate challenges, and ultimately formulate original research proposals within the field of tumor biology.

Possessing acute research acumen and the ability to translate clinical practice issues into research topics are essential competencies for the new generation of interdisciplinary medical professionals [11,12]. Consequently, fostering robust research awareness and capabilities has become crucial for assessing the quality of graduate students in medical-related fields. Writing research proposals significantly enhances graduate students' scientific thinking and demonstrates their comprehensive knowledge application. In the Practical Research Design module, educators present successful research proposals, elucidating each section, including the title, abstract, rationale, research content, methodology, and innovative aspects. Students, organized into groups, thoroughly read and discuss these proposals, identifying strengths and weaknesses, and engaging in academic debates. This process stimulates the generation of novel research ideas and enhances innovative thinking. Students then use preliminary experimental results provided by the teaching team to draft their own proposals, recording explanatory videos in English. Instructors offer personalized feedback on both the proposals and videos. This pragmatic training module significantly enhances graduate students' scientific thinking, research literacy, and innovative awareness, laying a solid foundation for advanced research capabilities.

3. Diverse Teaching Models

Given the characteristics of master's students, which include a robust theoretical foundation, extensive professional knowledge, and a strong inclination towards innovation, educational approaches should be individually tailored. Traditional teacher-centric lectures, mainly focused on transmitting theoretical knowledge, often fail to meet the needs for scientific research training and innovation promotion [13]. Consequently, we have implemented a "small class-seminar" format that emphasizes active student engagement, interpretative discourse, and practical application of concepts, thereby enhancing learning efficiency. Our course structure includes "pre-study on the Chaoxing platform, followed by one theoretical session (3 class hours) and one practical session (3 class hours)." In the "Solidifying Fundamentals" module, we use a hybrid online-offline teaching approach. Micro-lectures by expert researchers in tumor research are uploaded to the Chaoxing platform for pre-class study and online query resolution. Additionally, the in-person sessions integrate the latest tumor cell

biology research, providing in-depth theoretical explanations applied in practical settings, fostering deep reflection and stimulating student interest in the subject.

The second module, “Case Study Applications,” utilizes a case-based teaching method where instructors select experimental scenarios aligned with theoretical content to facilitate practical problem-solving. In the “Oncogenes and Tumor Suppressor Genes” section, students analyze RNA-seq data from tumor samples, create heatmaps and volcano plots, conduct GO and KEGG analyses, and design experiments to examine the role of CREB1 in lung cancer and its regulation of the oncogene KLF5. Students collaboratively complete these tasks and present their findings in class for evaluation on rationality, scientific rigor, feasibility, and teamwork. The third module, “Practical Research Design” is student-focused, requiring them to draft research proposals based on initial data and present these in English, detailing the project’s justification, scientific questions, experimental approaches, research pathway, and innovative aspects. This phase, enriched by interactive discussions, aims to boost students’ ability to integrate knowledge and refine their research skills. This educational strategy effectively merges theoretical learning with practical application, embodying a student-centered approach in small-group settings and enhancing the translation of theoretical knowledge into practical research.

4. Diversified Teaching Assessment

Teaching assessment and evaluation are pivotal mechanisms for quantifying students' learning outcomes, serving an indispensable role in gauging instructional efficacy and students' comprehensive competencies [14]. Through feedback on assessment results, educators can promptly identify deficiencies in their pedagogy, subsequently reflecting upon and refining their instructional methods and strategies, thereby elevating the quality and level of talent cultivation. Consequently, teaching assessment is not merely a requisite for fostering pedagogical reflection and enhancing instructional quality but also a crucial instrument for driving educational reform and development within academic institutions. In the context of the tumor cell biology course, which integrates theoretical knowledge with practical application, the methods of assessment and evaluation are critical in steering student development. To encourage students to establish a connection with real-world applications, emphasize practical experience, and translate their learning into tangible outcomes such as experimental designs and proposal writing, it is imperative to reform the traditional exam-centric evaluation methods. This necessitates the construction of a diversified assessment and evaluation system that is centered on student competencies.

In the tumor cell biology course, we balance formative and summative assessments, each accounting for 50% of the final grade. Formative assessments include attendance (5%), online learning activities (17.5%), class participation (25%), and quizzes (2.5%). Online activities on the Chaoxing platform involve mastering key concepts, creating mind maps, and conducting literature reviews, encouraging students to actively track their learning progress. Class performance is evaluated through group presentations with multi-level feedback from peers and teachers on educational effectiveness, teamwork, and analytical skills. Summative assessments consist of proposal writing and an English presentation, evaluated by teachers and mentors for quality, innovation, rationality, and feasibility, and by peers and the instructor for language skills and teamwork. This comprehensive, diversified approach not only monitors students’ learning trajectories but also enhances their critical thinking, problem-solving, subject understanding, research skills, experimental techniques, and innovation capabilities.

5. Conclusion

Tumor Cell Biology encompasses the fundamental theories of tumor cytology and molecular biology, integrated with research case analyses conducted by seasoned basic and clinical researchers at the forefront of oncological investigation, facilitating both teaching and practical research exercises.

Our pedagogical approach elucidates the classical theories and avant-garde developments in tumor cell biology in an accessible yet rigorous manner. We continually optimize course resources, enhance the pedagogical skills of our instructors, refine curricular designs, and intensify reform efforts to perfect the educational process, thereby achieving superior academic outcomes. The graduate course reform in Tumor Cell Biology was initiated with the 2020 cohort. Following four iterations of pedagogical reflection and refinement, the hybrid teaching model—combining online and offline modalities with both theoretical and practical components—has garnered unanimous approval from both faculty and students. By employing this integrative approach and leveraging modern information technology, we expand students' knowledge horizons and practical experience, effectively bridging the gap between theoretical knowledge and research practice. This instructional method aims to enhance graduate students' research acumen, self-directed learning, and innovative capabilities, thereby better equipping them to address global health trends and future development needs, and to meet the substantial societal demand for medical expertise.

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