# Teaching Exploration of Medicinal Chemistry Based on the Reform of the New Version Syllabus of the Licensed Pharmacist Qualification Examination

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**Abstract.** Medicinal chemistry is a compulsory part of the national licensed pharmacist qualification examination. Based on the reform of the new version syllabus of the licensed pharmacist examination, the exploration of the teaching reform of the medicinal chemistry curriculum was proposed from three aspects: 1) Guided by the national licensed pharmacist qualification examination, integrating the concept of licensed pharmacist into the course teaching; 2) Optimizing the teaching design, flexibly using a variety of teaching methods especially computer technology, paying special attention to the application of case teaching method; 3) Deepening the cooperation between school and enterprises, building and cultivating "double-qualified" teachers.

**Keywords:** Licensed pharmacist qualification examination, Reform of examination syllabus, Medicinal chemistry, Teaching exploration, Computer technology.

## 1 Introduction

Licensed pharmacists refer to pharmaceutical technicians who have passed the national unified examination, obtained the Professional Qualification Certificate of Licensed Pharmacists of the People's Republic of China, and are registered to practice in the production, distribution and use of drugs and other organizations that need to provide pharmaceutical services. The national licensed pharmacist qualification examination implements "three unification" of the examination system, that is, unified examination syllabus, proposition and organization. The examination is generally held once a year in October, and the examination syllabus is revised every five years. The current outline is the "National Licensed Pharmacist Professional Qualification Examination Syllabus" (8th edition), which was announced and implemented in March 2020. The 8th edition was revised based on the 7th, which was published in 2015 [1]. Different from the previous versions of the syllabus (referred to as the old version), which focused on assessing theoretical knowledge points and lacked practical examination, the 7th and 8th editions have undergone significant changes in terms of examination content, requirements and examination question types. These changes fully


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reflect the guiding principle of "learning for application, and application promote learning" [2]. We refer to the 7th and 8th editions as the new version syllabus.

Medicinal chemistry is a required subject in the pharmaceutical professional knowledge (I) for the qualification examination of licensed pharmacists. Due to its greater difficulty, many candidates are intimidated by the subject, which to some extent affects the pass rate of the qualification examination. Medicinal chemistry is a comprehensive discipline that is engaged in the discovery and invention of new drugs, the synthesis of chemical drugs, the clarification of medicinal chemical properties, and the study of the law of interaction between drug molecules and body cells. It has become a leading discipline in the field of pharmacy to communicate and integrate chemistry and life sciences [3]. The content of medicinal chemistry is very extensive, including the structure, name, physical and chemical properties, metabolism *in vivo*, drug synthesis, mechanisms of action, clinical applications, adverse reactions, structure-activity relationship (SAR) of drugs and so on. These are also the basic examination contents of the medicinal chemistry part in the pharmaceutical professional knowledge (I). To master these contents, students are required not only to have a foundation in basic chemical disciplines such as organic chemistry, inorganic chemistry, analytical chemistry, and biochemistry but also to integrate professional knowledge with pharmaceutical analysis, pharmacy and pharmaceutical administration. Moreover, the new syllabus has set higher requirements for pharmacology, clinical pharmacology, clinical medicine and clinical drug therapy. Candidates for the qualification examination of licensed pharmacists are almost all social candidates, with uneven cultural foundations, a wide age range, varying educational levels, and numerous work and life distractions. The difficulty of mastering the key points of medicinal chemistry and passing the examination in a short time is self-evident. Therefore, in the face of the reform of the new syllabus for the qualification examination of licensed pharmacists, as teachers of medicinal chemistry, we must teach the course well, laying a solid foundation for students to pass the qualification examination of licensed pharmacists after graduation.

## 2 Reform of the Examination Syllabus

The new syllabus is oriented towards the job competency of licensed pharmacists, based on the positioning and requirements of "examining based on use, scientific and reasonable, and ensuring ability", and focuses on improving the overall quality of the licensed pharmacists. It strives to better achieve the "commanding stick" role of the syllabus, which is "examining based on use, promoting learning through examination, and learning for practical use". While maintaining the "three basics" requirements, i.e. the basic theory, knowledge and skills, it gradually increases the ability of professional knowledge requirements to understand, use, analysis, synthesis and evaluate. The content takes into account the drug security-related requirements of the four major fields of drug production, wholesale, retail and use, and focuses on the comprehensive practice ability in drug quality management and pharmaceutical services that a li-

censed pharmacist should have. It strives to promote the healthy development of the licensed pharmacists through the standardized examinations [4].

Although the new syllabus stipulates that the examination subjects are still pharmaceutical affairs management and regulations, pharmaceutical professional knowledge (I), pharmaceutical professional knowledge (II) and pharmaceutical comprehensive knowledge and skills, great changes have taken place in the structure, breaking the structure of the old syllabus in accordance with the specific subject names and professional knowledge corresponding to higher pharmaceutical education, and adopting the form of integration and comprehensive. The specific changes are as follows: **1**) pharmaceutical professional knowledge (I): The old syllabus included 60% pharmacology and 40% pharmaceutical analysis. The new is integrated from the "three basics" of pharmacy, medicinal chemistry, pharmacology and pharmaceutical analysis, which greatly weakens the proportion of pharmaceutical analysis, accounting for only about 5%. **2**) pharmaceutical professional knowledge (II): The old outline included 60% pharmacy and 40% medicinal chemistry. The new is based on clinical pharmacology and combines knowledge of rational drug use and medication supervision from clinical therapeutics, achieving a perfect integration of the qualification examination and work for licensed pharmacists. **3**) pharmaceutical comprehensive knowledge and skills: The old outline's knowledge about medical devices has been removed, and a large amount of content on drug therapy for common diseases, guidance on rational drug use and health education has been added. **4**) pharmaceutical affairs management and regulations: The structure and format have been adjusted, changing from the old outline's compilation of pharmaceutical regulations to a problem-oriented format mainly for explaining and illustrating pharmaceutical regulations needed for the legal practice of licensed pharmacists. The specific compilation of laws and regulations is placed in the appendix, further strengthening the function of the subject in cultivating and educating the awareness of legality, the ability to practice legally, and noble professional ethics.

From an overall perspective, the new outline closely revolves around the role positioning of licensed pharmacists--guiding rational drug use, and is divided into two comprehensive practice abilities: the quality management of drugs and pharmaceutical services. The former focuses on cultivating the noble professional ethics and law-abiding qualities of licensed pharmacists, corresponding to the subject pharmaceutical affairs management and regulations; the latter emphasizes the assessment of licensed pharmacists' abilities to "recognize and understand drugs", "use drugs" and "use drugs for treatment" corresponding to the subjects pharmaceutical professional knowledge (I), pharmaceutical professional knowledge (II) and pharmaceutical comprehensive knowledge and skills, respectively.

In terms of question types, the new outline has retained the original types of questions while adding Type C questions. Type C questions, also known as comprehensive analysis multiple-choice questions, consist of a background information scenario and a set of questions based on that scenario. Each question is independent and has its own set of options. This type of question is similar to the north American pharmacist licensing examination, where most questions are presented in the form of cases [5]. It

is closer to the real work of licensed pharmacists and is better at assessing the candidates' comprehensive analytical abilities and pharmaceutical service skills.

## 3 Teaching Exploration of Medicinal Chemistry Course

At present, the main problems in the teaching of medicinal chemistry are as follows: 1) The course in major universities in China are generally short of class hours, and it is difficult to involve extended knowledge such as the latest progress of pharmaceutical research and cutting-edge technologies in life sciences. 2) Theoretical teaching is disconnected from clinical practice and cannot stimulate students' innovative ability. 3) The teaching method is single, and the traditional chemistry teaching mode is still adopted, so students have no motivation to learn actively. 4) There is a shortage of teachers who are truly skilled in medicine and knowledgeable in medications due to the lack of their own knowledge reserve.

The new examination syllabus adheres to the principle of "examining based on practical use". The reform of the new licensed pharmacist examination syllabus has prompted teachers to shift the focus of medicinal chemistry towards practical applications, particularly in pharmaceutical services. Therefore, the teaching of medicinal chemistry should also be restructured around the main theme of "prioritizing practical application" with a focus on rebuilding teaching content and methods. The author summarized many years of teaching experience and proposed a preliminary exploration of the teaching of medicinal chemistry based on the reform of the new licensed pharmacist qualification examination syllabus (**Figure 1**).

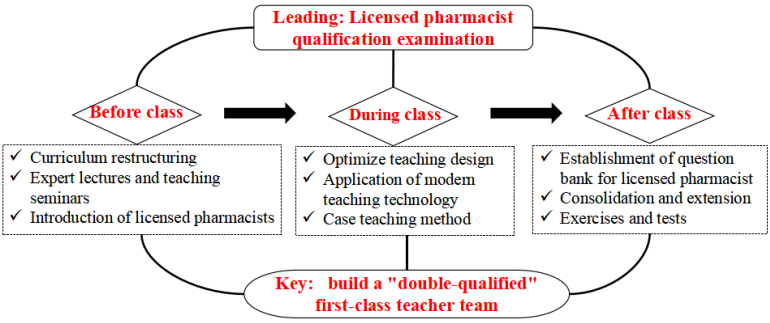


**Fig. 1.** Teaching exploration of medicinal chemistry based on the reform of the new version syllabus of the licensed pharmacist qualification examination.

### 3.1 Guided by the National Licensed Pharmacist Qualification Examination, the Concept of Licensed Pharmacist is Integrated into the Course Teaching

From the beginning of the course, through its implementation, to the final assessment, we should lead with the national licensed pharmacist qualification examination, integrating the philosophy of licensed pharmacists throughout the teaching of the course.

Before the start of the course, we will **1**) restructure the course outline of medicinal chemistry according to the reform of the new licensed pharmacist qualification examination syllabus. **2**) invite industry experts to give lectures, interpreting the policies on the management and qualification examination of licensed pharmacists. **3**) organize teachers to carry out teaching salons, discuss the teaching methods guided by the national licensed pharmacist qualification examination and integrating the concept of licensed pharmacist into teaching. **4**) purchase the relevant textbooks and reference materials of licensed pharmacists qualification examination in order to grasp the trends and information of licensed pharmacists. In the first class of medicinal chemistry, we will introduce the licensed pharmacists and their qualification examination to increase students' perceptual understanding and professional cognition of licensed pharmacists, set up the learning goal of licensed pharmacists, and motivate them to study medicinal chemistry hard for the future licensed pharmacists qualification examination.

In the implementation of teaching, we have abandoned the traditional chemistry teaching model and established a new teaching model that integrates chemistry, medicine and biology. Pharmacology is the most closely related to medicinal chemistry. Both of them are involved in the study of pharmacological action, mechanism of action and *in vivo* process of drugs, while mastering the chemical structure of drugs is helpful to accurately and deeply understand these contents [6]. In addition, clinical pharmacotherapeutics, pharmaceutical analysis, pharmaceutical management, pharmacokinetics and biopharmaceutics also have certain crossover with medicinal chemistry. Therefore, in the teaching process of medicinal chemistry, we have strengthened the cross-integration of medicinal chemistry and other disciplines to improve students' comprehensive quality and vocational skills, and to enhance the quality and level of pharmaceutical services.

In order to allow students to contact and understand the licensed pharmacist qualification examination as early as possible, we have collected the true questions of the medicinal chemistry part of pharmaceutical professional knowledge (I) for licensed pharmacist qualification examination in recent years, especially since the promulgation of the new syllabus. On this basis the medicinal chemistry question bank has been established, which aligns the types of questions, the knowledge points assessed, and the difficulty levels with the requirements of the licensed pharmacist qualification examination. This helps students master, understand and consolidate the main content of medicinal chemistry, and expand their knowledge of cutting-edge areas within the field. The assessment questions for the course each semester are also directly connected to the licensed pharmacist examination, covering all types of questions included in the exam, such as Type A, B, X and C questions. However, higher education in pharmacy is not solely focused on licensed pharmacist education, the teaching content and assessment requirements must also meet the standards for training pharmacy talents in higher education. Therefore, we have added writing and recognition chemical structures, short answer questions and so on to the exam question types to comprehensively evaluate the teaching effectiveness.

### 3.2 Optimize Teaching Design

The content of medicinal chemistry is numerous, involving multiple disciplines, and covers a broad range of knowledge points that often lack inherent connections. It is not feasible to teach all knowledge points indiscriminately within the limited class time. This requires teachers to focus on the key aspects of medicinal chemistry. Based on the reform of the new version syllabus, we have weakened the content of pure organic chemistry such as chemical naming, drug synthesis and reaction mechanism, and focused on the structural characteristics, drug metabolism, SAR and clinical application of common drugs.

In the design of the curriculum, a "modular design" approach has been implemented, dividing medicinal chemistry content into three major modules: chemistry, pharmacology and SAR. In "Chemical Module", the correlation between structure, physical and chemical properties and drug metabolism was established by using "structure determines physical and chemical properties" and "structure determines metabolic mode". "Pharmacological Module" uses "the toxic and side effects of drugs are a natural extension of drug action" to realize the organic association of drug action-clinical application-toxic and side effects-contraindications. "SAR Module" compares the similarities and differences between typical drugs and similar drugs, and summarizes the relationship of structure and activity [7].

### 3.3 Application of Modern Teaching Technology Especially Computer Technology

The teaching and learning of medicinal chemistry cannot be separated from the chemical structure, but its theory is too strong and boring, and it is difficult to attract students' learning interest. We need to change the outdated "cramming" and "full-class pouring" teaching methods, innovate educational teaching concepts, and achieve an organic integration of traditional and modern teaching. In the teaching process, we flexibly use a variety of teaching methods and means especially the applications of modern educational technology. The integration of computer technology in the teaching reform and practice of medicinal chemistry education has been an important trend in modern pharmaceutical education.

For example, we make full use of Augmented Reality (AR) and Virtual Reality (VR) technologies, and virtual laboratory technology in our teaching. AR and VR technologies can create three-dimensional models of chemical structures, allowing students to observe and manipulate drug molecules in a more intuitive way, enhancing the learning experience. Virtual lab technology is very helpful for understanding drug synthesis and reaction mechanisms. In addition, we have designed and developed medicinal chemistry online courses on network education platforms such as "Chaoxing Learning" and "Yu Classroom". By allowing students to self-study through videos and other materials before class, class time can be spent more on discussions and practical activities, increasing classroom efficiency. At the same time, the platforms can also help teachers manage course content, assignments, exams, and student feedback, while also providing students with a centralized learning platform.

While continuously exploring ways to improve the efficiency of classroom teaching, we also open up high-quality online resources for students, such as the MOOCs from China Pharmaceutical University (https://www.icourse163.org/course/CPU-1001570004) and "Xuetang Online" from Guizhou Medical University (https://www.xuetangx.com/course/gmc10071001163/19317689).

In summary, the application of computer technology in medicinal chemistry education not only boosts students' interest and engagement but also aids in a deeper understanding and mastery of medicinal chemistry knowledge, providing a solid foundation for future drug research and innovation [8].

### 3.4 Case Teaching Method

Given the reform of the new syllabus, which often draws questions from practical case studies, we have introduced specific cases into the teaching process and established a learning model of "case study + discussion + summary". Through case teaching, the leading role of teachers and the main role of students in the teaching process has been fully brought into play. For example, when teaching the chapter on anti-ulcer drugs in the digestive system, we used the following case: A patient, female, 68 years old, has been suffering from insomnia and has been taking diazepam. Recently, due to gastric ulcers, her doctor prescribed cimetidine. When she came to the hospital pharmacy to purchase diazepam, she complained that she was having difficulty exercising in the morning. This leads to a discussion: **1**) Whether the patient's difficulty in getting up early is a problem with medication. **2**) As a pharmacist, what medication advice do you have? Students, through group discussions and literature research, combined with knowledge of pharmacology and clinical drug therapy, finally reached the following consensus: **1**) The patient previously used diazepam for sleep without sedation, indicating that the physician's medication and dosage were appropriate, and there was no issue with medication errors. The recent difficulty in getting up early suggests that diazepam was still exerting central inhibition in the morning. However, the physician did not increase the dosage of diazepam; the increase in diazepam blood concentration was due to drug interactions after taking cimetidine. Literature research revealed that cimetidine is a liver enzyme inhibitor that can inhibit the metabolism of diazepam, leading to an accumulation of diazepam that still exerts central inhibition in the morning, preventing the patient from getting up early. **2**) To avoid drug interactions, it is suggested that the prescribing physician change cimetidine to an $H_2$ histamine receptor antagonist that is not a liver enzyme inhibitor, such as ranitidine or famotidine. It is precisely because of the side effects of cimetidine in drug interactions that it has driven pharmaceutical chemists to improve and discover more excellent $H_2$ histamine receptor antagonists, sparking a strong interest in learning among students.

Through case analysis and discussion, it can deepen students' knowledge, memory and understanding of theoretical knowledge learned in class, improve students' subjective initiative in learning, stimulate students' innovation ability and consciousness, truly make students become the subject of classroom teaching, stimulate the interest of clinical pharmacy students in learning medicinal chemistry, and improve the efficiency of classroom teaching [9].

### 3.5 Deepen the Cooperation Between Schools and Enterprises, and Build a First-class Team of "Double-qualified" Teachers

The key to talent cultivation lies in the teachers. As the designers, organizers, and implementers of the medicinal chemistry curriculum, the quality of teachers directly affects the quality of teaching. In order to adapt the teaching work of medicinal chemistry to the examination of licensed pharmacists and the development of pharmacy, schools should gradually strengthen the construction of teachers and build a first-class "double-qualified" teacher team. We encourage medicinal chemistry teachers to participate in the pharmacist licensing exam and obtain the pharmacist qualification certificate, leveraging their role as exemplary practitioners. Regularly sending teachers to the school's affiliated hospital pharmacy departments, pharmacies, or pharmaceutical factories for practical observation or temporary assignments allows them to fully understand the skill requirements of pharmaceutical professional positions and accumulate practical experience in pharmacy to integrate into the teaching of medicinal chemistry. At the same time, deepening industry-academia cooperation by inviting professional pharmaceutical technicians from pharmaceutical factories, pharmaceutical companies, or social pharmacies and hospital pharmacy departments, who understand theory and have practical experience, to serve as part-time teachers in universities can help make up for the shortage of "dual-qualified" teachers in colleges and optimize the teaching staff.

## 4 Teaching Result

### 4.1 Materials and Methods

The survey objects of the evaluation of teaching reform were the students in the second semester of 2017. The objects of employers' satisfaction with students were the students who graduated after the teaching reform. Taking the launch of the medicinal chemistry curriculum reform in 2016 as the node, the statistics of the four consecutive graduates from 2017 to 2020 participated in the national licensed pharmacist examination were carried out. Students majored in pharmacy and pharmaceutical preparation. Employers included hospitals, pharmaceutical enterprises, pharmaceutical trading companies and other organizations.

The survey method was a combination of survey statistics and questionnaires. The counselors of our school were commissioned to pay a return visit to the students after graduation, and statistical analysis was made on the situation and passing rate of the graduates who participated in the national licensed pharmacist qualification examination. The questionnaires were divided into two categories. One was filled out by students, and the content was the students' satisfaction with the teaching reform of medicinal chemistry. A total of 106 questionnaires were randomly sent out, 104 were recovered, and 104 were valid, with a recovery rate of 98.1%. The other category was filled out by the employers, the key content was the employer's evaluation of the degree of satisfaction of the graduates after the teaching reform. 207 questionnaires

were issued, 202 were recovered, and 201 were valid. The questionnaire recovery rate was 97.6%.

### 4.2 Results

**Students' Evaluation of Teaching Reform.**

**Table 1.** Results of after-class questionnaire survey (%).

| Content of teaching reform | Satisfaction | Dissatisfaction | No comment |
|---|---|---|---|
| Syllabus adjustment | 90 | 6 | 4 |
| Teaching design (Modular design) | 96 | 2 | 2 |
| Application of modern technology | 86 | 10 | 4 |
| Teaching method (Case teaching) | 92 | 5 | 3 |
| Teaching faculty | 88 | 7 | 5 |
| Curriculum overall evaluation | 95 | 3 | 2 |

As shown in **Table 1**, students have a high degree of satisfaction with the curriculum reform. The curriculum reform has been recognized by students in enhancing the pertinence of medicinal chemistry teaching and meeting the needs of students' growth and development.

**Employer's Survey of Student Satisfaction and the Statistics of Passing Rate of Licensed Pharmacist Qualification Examination.**

Questionnaires were issued to employers to investigate their satisfaction with the graduates of our school after the teaching reform (**Table 2**). The evaluation results are as follows: (1) The overall satisfaction of the employers to the graduates of pharmaceutical majors in our school is 86%, and it is generally believed that the graduates have strong adaptability to the job. (2) The hospital pharmacy had the highest degree of satisfaction for graduates, which was 92%, especially that the pharmaceutical care ability of graduates had been greatly improved in recent years.

**Table 2.** Survey results of employers on student satisfaction (%).

| Employer | Satisfaction | Dissatisfaction | No comment |
|---|---|---|---|
| Pharmaceutical enterprise | 85 | 8 | 7 |
| Hospital pharmacies | 92 | 5 | 3 |
| Social pharmacies | 90 | 6 | 4 |
| Other organizations | 84 | 10 | 6 |
| Total | 86 | 8 | 6 |

The statistics of graduates participating in the national licensed pharmacist examination were shown in **Table 3**. The passing rate of pharmaceutical professional knowledge (I) increased by 4.8% after the implementation of teaching reform and the rate of the examination one time increased by 3.2%.

**Table 3.** Statistics of passing rate of licensed pharmacists qualification examination.

| Examination time | Pharmaceutical professional knowledge (I) (%) | All subjects (4 subjects) (%) |
|---|---|---|
| Before teaching reform | 10.4 | 9.8 |
| After teaching reform | 15.2 | 13.0 |

## 5 Conclusion

Licensed pharmacists play a crucial role in drug quality management and providing pharmaceutical services, ensuring the rational use of medication, and safeguarding public health. Through the efforts of national drug regulatory authorities and related departments over the years, the number of licensed pharmacists has been steadily increasing. As of the end of July 2024, there were a total of 803,784 licensed pharmacists registered within the validity period nationwide, with an average of 5.7 pharmacists per 10,000 people [10]. Currently, the main contradiction in China's licensed pharmacists workforce has shifted from a shortage of quantity to a lack of overall quality, with a high proportion of pharmacists at lower educational levels, which creates a significant gap compared to the socio-economic development and the increasing demand for safe and rational drug use by the public [11]. The reform of the licensed pharmacist examination outline closely grasps this main contradiction, emphasizes "people-centered" pharmaceutical services, and focuses on comprehensive and practical aspects. In our teaching practice, we continuously have deepened industry-academia cooperation to build a first-class "dual-qualified" teaching team. Based on the reform of the new examination outline, we have reorganized the medicinal chemistry curriculum, guided by the national licensed pharmacist qualification examination, integrating the concept of licensed pharmacists throughout the teaching process. We have optimized teaching design, flexibly applied various teaching methods, established a "case study + discussion + summary" learning model, and built a more effective classroom to improve teaching quality and cultivate students' abilities in comprehensive analysis, problem-solving, and pharmaceutical services. By implementing these measures, educational institutions can better prepare students to meet the evolving needs of the pharmaceutical industry, ensuring that future pharmacists are well-equipped to provide high-quality pharmaceutical services and contribute to the health and well-being of the community.

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