Reform of Teaching Practice of *Modern Instrumental Analysis* in Biotechnology Programs

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Abstract Through the online and offline practical reform of the *Modern Instrumental Analysis* course of biotechnology majors from teaching content, teaching method, teaching demonstration to teaching effect, the traditional single offline lecture is transformed into diversified and interactive modern teaching. The practical reform enriches and optimizes the course content, perfects and improves the course assessment system, and improves the teaching quality. It achieves the student-centered and application-oriented teaching goal, and also provides reference for further cultivating high-quality applied talents.

Key words *Modern instrumental analysis*; Biotechnology; Online and offline; Reform of teaching

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Modern instrumental analysis is a practical analysis method using complex or special instruments and equipment[1]. This course has a wide and diverse range of content, involving interdisciplinary fields such as mathematics, physics, chemistry, and computer science. It includes basic theoretical research as well as cutting-edge instrument process, covering a wide range of knowledge, and has strong technicality and practicality[2]. With the rapid development of science and technology, modern instrumental analysis has been developing in the direction of multi-function, automation, intelligence, specialization and miniaturization, so mastering modern instrumental analysis techniques plays an important role in the future career or research work of students majoring in biotechnology[3].

Modern instrumental analysis belongs to the examination course of biotechnology majors in our college. Due to that the class hours are only 32 h, the teaching method based on traditional blackboard writing or PPT explanation is relatively simple, which will make students feel that the content is abstract and obscure, the structures of instruments are complicated and difficult to be understood, and students will easily lose interest in learning if they can't keep up with the teaching rhythm[4]. Especially since 2020, because the rhythm of offline teaching will change from time to time, it is often necessary to combine online and offline teaching, so it is urgent to carry out comprehensive teaching reform on online and offline methods. To this end, we adopted the "online + offline" mixed and diversified teaching method for this course, and established a student-centered and application-oriented teaching goal. After three years of course practice, satisfactory results have been achieved in teaching content, teaching methods and teaching effects. The following summarized our experience in teaching practice reform of this course for reference by peers[5].

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Reform of Offline Teaching

Reform of offline teaching content: optimizing and supplementing teaching content

In the teaching content, firstly, the 18 chapters involved in this course were divided into "four sections" according to the professional characteristics of biotechnology, that is, according to the basic principles of instrumental analysis, the 18 chapters were classified into spectral analysis, chromatographic analysis, electrochemical analysis and other analysis methods (mass spectrometry, thermal analysis, *etc.*), so that the outline teaching structure is clear, and students can easily grasp the main context of the course. Moreover, the key and difficult points involved in the structural analysis of "four major spectra" (ultraviolet UV, infrared IR, nuclear magnetic resonance NMR, mass spectrometry MS) in spectroscopic analysis were dissected.

Secondly, according to commonly used instrumental analysis methods in the field of biotechnology, combined with the future development direction of modern biological instruments, related contents of biotechnology were introduced, such as fluorescence flow cytometry, fluorescence quantitative PCR, patch clamp technique and gene chip technique. Meanwhile, referring to students' actual situation, difficult contents in the course and the contents that play an important role in the research or application in the field of biology were mainly explained, such as the principle and application of capillary electrophoresis, the separation and sequencing methods of nucleic acid protein, *etc.* In this way, the teaching content becomes concise, three-dimensional, and rich in hierarchy, making it clear at a glance. Students could easily master the basic principles of various chapters through horizontal and vertical comparison methods, and grasp the development direction of instrumental analysis in the field of biotechnology.

Reform of offline teaching methods: flexible use of multi-dimensional teaching methods

In the classroom, teachers need to pay close attention to students' listening status while explaining the teaching content, and adjust the teaching methods in time, and perform cross adjustment using various teaching methods flexibly, so as to firmly grasp students' attention, let students follow the classroom content and study deeply, and improve their interest in learning. Several common multi-dimensional teaching methods can be divided into example-based, group-based, interactive, inductive, online search-based, questioning-based, and video watching methods. The following are several commonly used teaching methods:

Because many contents of modern instrumental analysis are related to the quantitative analysis of substances, it will be difficult for students to master complex formulas without giving examples and doing exercises[6], so "giving examples" is a common teaching method in multi-dimensional teaching methods. For example, the quantitative analysis method of "standard addition method" in atomic absorption spectrometry is usually a difficult content in students' study, which is not easy to understand and master. Therefore, after we finished teaching of the measurement method and principle of "standard addition method" in class, a test question of measuring zinc content in a plant sample by atomic absorption spectrometry was given in class. First, students were given a certain period of time to solve the problem, then students were assigned to write on the blackboard to solve the problem, and then comments were made step by step according to the problem solving situation. Therefore, by letting students do first, then teaching, and then listening to teachers' decomposition, it can quickly draw students' attention in class, effectively improve their mastery and understanding of knowledge points, and enhance their ability to solve practical problems by using what they have learned. This method is much more effective than ruling by teacher's voice alone in the classroom.

Secondly, the teaching method of "grouping" is the key content of this teaching method reform, because the technical methods explained in *Modern Instrumental Analysis*, the textbook designated by Liu Yuequan, are more suitable for agriculture, forestry, water and other majors[7], and there is no explanation on the technical content of modern biological instrument analysis. For this reason, we referred to cutting-edge analytical techniques in textbooks such as *Modern Biological Instrument Analysis* and *Modern Biological Instrument and Equipment Analysis Techniques*, and then arranged students to inquire about these techniques after class in groups, and then report, comment and summarize them in class. Through this teaching method, students were regularly supplemented with the contents of the development and evolution, determination principles, basic structures, application scopes and other aspects of expanded techniques such as transmission and scanning electron microscopy, fluorescence quantitative PCR and fluorescence flow cytometry[8-9].

In addition, "online inquiry" and "questioning" can be used alternately in classroom teaching, that is, using modern network, students can consult the business information of key instruments to deepen their understanding of the instruments. For example, when we taught the basic composition and structure of high performance liquid chromatograph (HPLC) in class, we immediately asked students to inquire about various HPLC instrument online and compared the prices, basic information and characteristics of various types of chromatograph. This method is time-sensitive, enlivens the classroom atmosphere and arouses students' thirst for knowledge.

Reform of Online Teaching

Online teaching, combined with offline teaching, can play a powerful role of informationization, integration and convenience, and better guide and manage teaching. Commonly used teaching softwares include Superstar Learning Link, Tencent Meeting, Rain Classroom and Wisdom Tree. For this course, Learning Link was mainly used to reform the teaching demonstration and teaching effect evaluation of instruments[10].

On-line teaching demonstration of high, precise and sophisticated modern instruments

Because this course is an examination course and there is a lack of experimental course setting, it is easy for students to feel bored and afraid of difficulties just by watching textbooks, writing on the blackboard in class or explaining by PPT. Therefore, using high-definition video demonstration of offline teaching can enhance students' intuitive understanding and mastery of modern instrument structures and analysis principles, and improve their interest in learning. In the method, teachers collect and integrate the explanation videos of important and precious precision instruments such as gas chromatograph, high performance liquid chromatograph, nuclear magnetic resonance spectrometer, mass spectrometer and infrared spectrum analyzer before teaching, and play or store the videos in the learning materials in class. In this way, students can not only understand the main structure, basic principles and operation methods of high, precise and sophisticated instruments in class, but also consult and watch them repeatedly at any time after class.

Synchronous online evaluation of teaching effect

For how to check students' listening and learning effects, it can be easily completed by skillfully using the "homework" or "exam" function of Superstar Learning Link, which greatly saves teachers' time to correct homework or test papers and improves the efficiency of quality evaluation. For example, using the "homework" function of Superstar Learning Link can realize the automatic distribution, automatic marking, automatic evaluation and statistics of homework. In this method, teachers put each chapter's homework into the "learning library" of the "homework" function in Superstar Learning Link in advance, and set the distribution time and marking method of each chapter's homework in advance, and the learning link system will distribute homework questions at the specified time, and after the students submit their homework,

the statistical information system will automatically upload and display the homework completion ratio of the whole class and the score of each student. This evaluation method allows teachers to observe students' learning situation in time and adjust the teaching plan in time. It can also help students to "check and fill in the gaps", consolidate what they have learned in class in time, and grasp the important and difficult contents of each chapter more clearly. In 2022, we used the Learning Link to publish online homework for students majoring in biotechnology for 13 times, including 173 questions. The results showed that the students' homework completion rate was 100%, and the score was highest at 100 points and lowest at 64 points, with an average of 95.37 points[11]. Hence, this method realized the synchronous evaluation of teaching effect.

Conclusions

In the era of networked information education, offline teaching must be deeply integrated with online teaching software to improve teaching quality and teaching effect[12]. In this paper, the teaching practice reform of the *Modern Instrumental Analysis* course for biotechnology majors was carried out from teaching content, teaching methods, teaching demonstration to teaching effect, and the traditional single offline teaching mode was been transformed into a diversified and interactive "online + offline" mixed multielement teaching mode, making the teaching activities of the course more interactive, interesting, enlightening and practical[13]. This reform not only greatly enriches the teaching resources for students, enhances the subjective initiative of learning, and effectively improves the overall quality of theoretical course teaching, but also provides reference for cultivating high-quality applied talents[14-15].

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