Education Reform and Development, 2025, Volume 7, Issue 5
https://ojs.bbwpublisher.com/index.php/ERD
Online ISSN: 2652-5372
Print ISSN: 2652-5364

Thoughts on the Teaching Method Reform of the "Bioinstrumental Analysis" Course for Biology Majors in Universities

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Abstract: This paper explores the reform of the teaching method of the "Bioinstrumental Analysis" course for university biology majors. By analyzing the existing problems in current teaching, this paper proposes a series of targeted solutions to improve teaching effectiveness and cultivate students' practical abilities and innovative thinking. The article first outlines the importance of the "Bioinstrumental Analysis" course and the limitations of current teaching methods, then discusses the necessity of reform in detail, and proposes specific reform strategies, including interactive teaching, case analysis, and project-based learning. Finally, the article summarizes the expected results of the reform and its implications for future teaching.

Keywords: Bioinstrumental analysis; Teaching method reform; Interactive teaching; Case analysis; Project-based learning

Online publication: May 30, 2025

1. Introduction

Bioinstrumental analysis constitutes a core component within the undergraduate curriculum for biological sciences, serving as an integrative discipline that systematically bridges fundamental theories, analytical methodologies, and practical implementation strategies. This interdisciplinary course encompasses three critical dimensions: (1) theoretical frameworks of modern analytical techniques, (2) operational principles of advanced instrumentation, and (3) their comprehensive applications in biological research and industrial practice [1,2]. Bioinstrumental analysis provides students with theoretical knowledge for analyzing biological samples and cultivates students' experimental skills and scientific thinking.

The instructional efficacy of bioinstrumental analysis curricula exerts profound impacts on students' professional competencies and career trajectories within the biotechnology sector. With the rapid development of bio-analytical instruments, new theories and methods are constantly emerging [3,4]. However, the knowledge

update of instructors often lags behind the development of instruments, making it difficult to impart the latest knowledge and technology to students. The "Bioinstrumental Analysis" course involves knowledge from multiple disciplines such as physics, chemistry, biochemistry, and advanced mathematics, which makes it difficult for students to understand when facing complex interdisciplinary knowledge [5,6]. Coupled with the large amount of course content, students have difficulty systematically completing the learning of basic theories and are even more difficult to apply the learned knowledge to practical operations, resulting in a lack of learning interest and motivation. Traditional teaching methods often focus on the imparting of theoretical knowledge, neglecting the active participation of students and the cultivation of practical abilities [7]. This paper will explore the problems existing in current teaching methods and propose corresponding reform strategies.

2. Problems existing in current teaching methods

2.1. Disconnection between theory and practice

The traditional teaching model mainly focuses on the explanation of theoretical knowledge. Students passively receive knowledge in class and lack opportunities for practical operations. This teaching method makes it difficult for students to combine theoretical knowledge with practice when facing practical problems, affecting their ability to solve practical problems. For example, students may understand the principle of a certain analysis technique in class, but they are unable to skillfully operate the relevant instruments in the laboratory and accurately analyze biological samples.

2.2. Low student participation

The teacher-dominated teaching model in the classroom puts students in a passive position of acceptance, lacking opportunities for active participation and thinking. This one-way teaching method is not conducive to stimulating students' learning interest and enthusiasm, resulting in a lack of in-depth understanding and mastery of the course content. For example, when teachers explain complex analysis methods, students may feel bored due to the lack of interaction, unable to concentrate, thus affects the learning process.

2.3. Lagging update of teaching content

With the rapid development of science and technology, new technologies and methods are constantly emerging in the field of bioinstrumental analysis [8]. However, the update of teaching content often lags behind the development of the discipline, resulting in a gap between the knowledge learned by students and practical applications, unable to meet the needs of modern biological scientific research and industrial development. For example, some of the latest analysis techniques, such as single-cell mass spectrometry analysis and high-throughput sequencing, have been widely used in scientific research, but they are rarely covered in textbooks and teaching content.

3. The necessity of teaching method reform

3.1. Meeting the needs of discipline development

The rapid development of bioinstrumental analysis technology requires that teaching content and methods be updated in a timely manner to meet the needs of discipline development [9]. Reforming teaching methods and introducing new teaching concepts and technologies can help students master the latest analysis techniques and

methods and improve their professional competitiveness. For example, by introducing cases of the latest analysis techniques, students can understand the current research frontiers and lay a solid foundation for future scientific research work.

3.2. Cultivating innovative thinking and practical abilities

Modern biological scientific research and industrial development require students to have not only solid theoretical knowledge but also innovative thinking and practical abilities. By reforming teaching methods and increasing students' practical operations and innovation training, the comprehensive quality of students can be effectively cultivated, laying a foundation for their future development. For example, by designing open-ended experimental projects and encouraging students to independently design experimental plans, students' innovative and problem-solving abilities can be cultivated.

3.3. Improving teaching effectiveness and student satisfaction

Reforming teaching methods and improving students' participation and initiative can help improve teaching effectiveness and students' satisfaction with the course. When students actively participate in the learning process, they can better understand and master the course content, thereby improving the learning effect and interest. For example, through group discussions and project reports, students can learn from each other, make progress together, and enhance their sense of achievement in learning.

4. Strategies for teaching method reform

4.1. The four-round integrated teaching model

The four-round integrated teaching model includes the integration of explicit knowledge and implicit values, the integration of online and offline teaching, the integration of problem-driven and visual teaching, and the integration of theoretical learning and research practice [10]. This model combines multiple teaching methods to stimulate students' learning interest and innovative practical abilities. For example, through the four "shi" (history, current events, facts, and poems), ideological and political elements such as "scientific and innovative spirit," "patriotic feelings," "professional ethics," and "humanistic qualities" are integrated into classroom teaching to implement the fundamental task of cultivating people with moral integrity.

4.2. Project-based teaching method

The project-based teaching method uses projects as carriers to combine theoretical knowledge with practical operations. Through specific project tasks, students are guided to carry out independent learning and teamwork. For example, design a project on the analysis of specific components in a certain biological sample. Students need to operate and research in various links from sample collection, pretreatment, to analysis and detection. This method not only improves students' practical abilities but also cultivates their scientific research thinking and innovative abilities.

4.3. Case analysis teaching method

By selecting typical bioinstrumental analysis cases, students are guided to analyze and discuss. For example, analyze a case of biomarker detection in a certain disease diagnosis, allowing students to understand the importance and specific operation steps of bioinstrumental analysis in practical applications. This method can

combine theoretical knowledge with practical problems and improve students' ability to solve practical problems.

4.4. Task-driven project-case teaching method

The task-driven project-case teaching method combines the task-driven teaching method and the case-based teaching method. By designing specific project tasks, students are guided to carry out independent learning and collaborative completion of the established project tasks. This method not only improves students' practical abilities but also cultivates their teamwork abilities and innovative thinking. For example, design a project on the detection of food additives. Students need to master the relevant analysis techniques and methods by completing specific tasks.

4.5. Thinking-oriented teaching model

Through four links of problem introduction, knowledge formation, application transfer, and classroom reflection, students are guided to think deeply and learn independently. For example, when explaining the ultraviolet-visible absorption spectroscopy method, the measurement principle and application are introduced by measuring the content of VC, and students are guided to conduct group discussions and experimental operations. This method can not only improve students' theoretical knowledge level but also cultivate their innovative thinking and practical abilities.

4.6. Industry-education-research integrated teaching method

By cooperating with enterprises and scientific research institutions, actual scientific research projects and production practices are introduced into the classroom. For example, organize students to intern in enterprises and institutions such as analysis and control testing centers and environmental monitoring stations. Combined with the actual situation and needs of the units, students conduct the analysis and detection of actual samples. This method can not only improve students' practical abilities but also enhance their career planning awareness.

4.7. Ideological and political teaching methods in courses

By integrating ideological and political elements into the course, students' patriotic feelings and professional ethics are cultivated. For example, when explaining bioinstrumental analysis technology, combined with the scientific research progress and application cases in this field in China, students' patriotic enthusiasm and scientific research interest are stimulated. This method can not only improve students' theoretical knowledge level but also cultivate their sense of social responsibility and professional ethics.

4.8. Online teaching platform and virtual simulation teaching

By using online learning platforms such as China University MOOC, high-quality experimental teaching resources are introduced to match the explanation of theoretical courses, enabling students to more intuitively understand the principles of instrument analysis and experiments. At the same time, through training on virtual simulation platforms, students' experimental operation abilities and learning experiences are improved. This method can not only improve classroom activity and learning efficiency but also achieve the cross-semester connection between theory and experiment.

4.9. Open-ended bioinstrumental analysis technology improvement project

In the form of after-class assignments, students are encouraged to conduct innovative thinking training. For

example, assign open-ended tasks for instrument technology improvement, allowing students to conduct independent research and innovative design after class. This method can not only improve students' innovative abilities but also cultivate their independent thinking and problem-solving abilities.

4.10. Interactive teaching and classroom discussion

Through methods such as questioning, discussion, and group cooperation, students are guided to actively participate in classroom learning. For example, when explaining a certain analysis technique, the teacher can ask relevant questions, let students discuss in groups, and then each group selects a representative to report. Through this method, students can not only deepen their understanding of knowledge but also cultivate teamwork and communication abilities.

5. Expected results of the reform

5.1. Improving students' practical abilities and innovative thinking

Through reform strategies such as interactive teaching, case analysis, and project-based learning, students can participate more in practical operations and innovation training, effectively improving their practical abilities and innovative thinking [11]. In the process of completing projects and case analysis, students can learn how to apply theoretical knowledge to solve practical problems and cultivate independent thinking and problem-solving abilities. For example, in project practice, students can improve their experimental design and data analysis abilities and cultivate innovative thinking by independently designing experimental plans and analyzing data.

5.2. Enhancing students' learning interest and enthusiasm

The reformed teaching methods pay more attention to students' active participation and experience, which can stimulate students' learning interest and enthusiasm. When students actively participate in classroom discussions and project practices, they can feel the fun and sense of achievement of learning, and thus be more actively involved in learning, improving the learning effect. For example, through group cooperation and project reports, students can learn from each other, make progress together, and enhance their sense of achievement and self-confidence in learning.

5.3. Promoting the update and optimization of teaching content

The introduction of interactive teaching and case analysis methods requires teachers to constantly update and optimize teaching content to meet the needs of practical applications. When preparing cases and projects, teachers need to pay attention to the latest development trends in the field of bioinstrumental analysis and introduce new technologies and methods into the teaching content, thus promoting the update and optimization of teaching content and improving the timeliness and practicality of teaching. For example, teachers can keep abreast of the latest developments in the discipline by participating in academic conferences and reading the latest scientific research literature, and update the teaching content.

6. Conclusion

The teaching method reform of the "Bioinstrumental Analysis" course is an inevitable choice to meet the needs of discipline development and cultivate high-quality biology professionals [12,13]. By implementing reform strategies

such as interactive teaching, case analysis, and project-based learning, the problems existing in the current teaching process can be effectively solved, students' practical abilities and innovative thinking can be improved, students' learning interest and enthusiasm can be enhanced, and the update and optimization of teaching content can be promoted [14,15]. In the future, we should continue to explore and practice more effective teaching methods, continuously promote the teaching reform of the "Bioinstrumental Analysis" course, and contribute to the cultivation of biology professionals who meet the needs of modern society. Teachers should constantly reflect on teaching practices, collect students' feedback, and continuously improve teaching methods to ensure the sustainability and effectiveness of teaching reform.

Funding

Undergraduate Education and Teaching Research and Reform Project of Autonomous Region Universities (Project No.: XJGXPTJG-202229)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Chen G, 2014, Characteristics and Teaching Exploration of the "Biotechnology Instrumental Analysis" Course. Light Industry Science and Technology, 30(10): 125–126.

[2] Zhao C, Liu W, Shao J, et al., 2019, Discussion on the Experimental Teaching Reform of the "Instrumental Analysis" Course. Modern Agricultural Science and Technology, 2019(1): 253–254.

[3] Sha X, Zhang L, 2018, Teaching Reform and Innovation of Bioinstrumental Analysis in the Era of Artificial Intelligence. Educational Informatization Forum, 2(2): 53–54.

[4] Sha X, Chen W, Zhang L, 2018, Practical Exploration of New Media in the Teaching Reform of Bioinstrumental Analysis. Education Modernization, 5(15): 68–69.

[5] Li Y, Lin Y, Liu W, et al., 2022, Teaching Reform and Practice of the "Bio-chemical Instrumental Analysis" Course Based on the Cultivation of Students' Practical Innovation Ability. Chemistry of Life, 42(6): 1230–1237.

[6] Zheng Z, Zhao C, Shao J, et al., 2020, Teaching Reform of the "Bioinstrumental Analysis" Course under the Background of New Engineering. Modern Agricultural Science and Technology, 2020(23): 250–252 + 255.

[7] Zhang J, Wang M, 2020, Exploration of the Teaching Reform of Instrumental Analysis for Application-oriented Biotechnology Majors. Shandong Chemical Industry, 49(19): 169–170.

[8] Si Z, Lu L, Jiang N, et al., 2024, Teaching Construction and Reform of the "Biochemical Instrumental Analysis" Course for Bio-engineering Majors. Chinese Journal of Bioprocess Engineering, 22(4): 447–453.

[9] He C, Shao Z, Zhang X, et al., 2025, Teaching Reform and Practice of Ideological and Political Education in Biomedical Professional Courses—Taking "Instrumental Analysis" as an Example. Journal of Yunnan Minzu University (Natural Sciences Edition), 2025: 1–11.

[10] Cao M, Zhang Y, Song X, et al., 2024, Teaching Innovation and Practice of Higher Vocational Architectural Design Courses Based on the "Four-wheel Drive" Mechanism under the Background of Industry-Education Integration. Vocational Technology, 23(4): 94–102.

[11] Xue Y, Xiong F, Yuan H, 2023, Reform Practice of the Flipped Classroom Teaching Model for Instrumental Analysis Experiments. Journal of Nantong Vocational University, 37(3): 53–57.

[12] Zhang J, Zhang X, 2018, Discussion on the Teaching Reform of Bioinstrumental Analysis. Educational Informatization Forum, 2(6): 81 + 96.

[13] Zhao H, Yan Q, Hu M, 2022, Exploration of Practice-oriented Teaching in the Reform of Postgraduate Courses—Taking the "Biological Analysis and Testing Techniques and Instruments" Course as an Example. Education Teaching Forum, 2022(47): 77–80.

[14] Huang Y, Ma L, Chen H, et al., 2019, Exploration of the Theoretical and Practical Teaching Reform of Bioinstrumental Analysis. Journal of Biology, 36(5): 108–111.

[15] Li Y, 2015, Exploration and Thoughts on the Teaching Reform of Bioinstrumental Analysis. Beijing Agriculture, 2015(3): 271.

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