

Exploration of Research-Based Classroom Teaching Model in the Teaching of Biochemistry and Molecular Biology

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ABSTRACT

Our research group practiced a research-based teaching model in the teaching of biochemistry and molecular biology. The influence of this teaching model on students' final exam score was analyzed. The results showed that in the final exam, the average score of the students taught using the research-based classroom teaching mode was 64.3 ± 10.5 (Mean \pm Std) points, which was similar to the score of 64.3 ± 12.2 (Mean \pm Std) points of the students taught using the traditional teaching mode ($P > 0.05$). However, there are significant differences in the score of essay questions ($P < 0.05$). The essay questions mainly examine the students' scientific research literacy, the ability to utilize professional knowledge to analyze and solve problems, the ability to develop logical reasoning, and so on. Therefore, our results indicate that the research-based classroom teaching model can cultivate and improve students' scientific research literacy mentioned above and is worthy of promotion and application.

Keywords: *scientific research literacy, research-based classroom teaching model, biochemistry teaching, molecular biology teaching, final exam*

1. INTRODUCTION

Society's demand for high-quality and innovative talents in the new era requires colleges and universities to carry out in-depth classroom teaching reforms. Therefore, many teaching models have emerged, such as flipped classroom[1], team-based learning (TBL)[2], presentation-assimilation-discussion (PAD)[3], Microteaching[4], brain-targeted teaching model[5]. Scientific research literacy is the basic one of undergraduate students in the new era. Therefore, university education should allow students to participate and experience the scientific research practice process and scientific research method ideas, and then cultivate students' scientific research interest, scientific research habits, scientific research thinking ability, innovative ability and collect scientific research information, condensing scientific research ideas or directions, and even the writing ability of scientific research papers. A large number of studies have been used to explore effective ways to construct a scientific research-based teaching model from many aspects. For example, Li et al. [6] took agricultural biotechnology-related courses as the research object, and introduced the basic elements of scientific research into the teaching, from the selection of textbooks, curriculum theory, classroom discussion, curriculum practice, and curriculum assessment to explore

the operating mechanism of the scientific research-based teaching model aimed at cultivating students' scientific spirit, creative thinking and innovative ability. Yang et al. [7] discussed and tried to teach on the goals, specific methods and applied teaching practice of writing scientific research lectures from the perspective of the compilation and practice of scientific research lectures for basic courses in colleges and universities in ethnic regions. Xie and Zhou [8] integrated the cultivation of students' scientific research thinking ability with the four aspects of teaching content, teaching methods, assessment methods, and practical links, and constructed a high-quality polymer chemistry and physics foundation with the characteristics of "research-based teaching" course. Yuan and Deng[10] introduced the transgenic zebra fish technology to gene engineering experimental course of undergraduate students, and achieved good results. Agarwal et al. [11] constructed an online educational model in andrology. They effectively carried out student training in the art of scientific writing in the COVID-19 pandemic around research writing projects. In the first and second grades of the university, through inspiring and encouraging students to conceive, write and practice scientific research projects, and even essay writing, it is indeed possible for students to get in touch with scientific research early, understand the rules of scientific research, and cultivate students' interest in scientific research and train students' scientific research thinking habits, scientific research practice ability, and

innovation ability, so as to improve students' scientific research literacy during scientific research activities. However, students have limited time and energy. In order to ensure that students can learn more knowledge and have more opportunities to exercise in the limited time and energy, without affecting other aspects of learning, we propose to practice a scientific research-based classroom teaching model in the teaching of biochemistry and molecular biology, so as to closely integrate the application of scientific research projects and project research for college students to carry out practical teaching. In addition, in order to meet the online + offline teaching needs and learning environment under the COVID-19 pandemic, we combine the theoretical and experimental content of biochemistry and molecular biology with the application of college students' innovative scientific research projects, the participation of scientific research projects, and the writing of paper to carry out an integrated scientific research and teaching model using online and offline learning. Finally, we analyzed the impact of the scientific research teaching model on students' final exam score and other aspects of improving scientific research literacy ability, and explored its possible role in the teaching of biochemistry and molecular biology. The following is a brief overview of it.

2. MATERIALS AND METHODS

2.1. Subjects of Educational Reform

A total of 11 classes of students enrolled in the undergraduate clinical medicine major at Youjiang Medical College for Nationalities in 2021, with a total of 645 students as the subjects of this study, showed no significant differences in student enrollment performance among classes. Among them, 95 students in classes 1 and 2 implemented classroom teaching through an integrated online and offline research teaching model, and 26 others did not choose research project application and thesis writing, which will be analyzed in a separate paper and ignored in this statistical analysis. In contrast, 524 students in classes 3-11 implemented the traditional teaching model.

2.2. Methods of Teaching Reform

(1) Teachers will release teaching tasks 2 weeks ago by relying on the Chinese University MOOC Platform and Exam Cool Platform. This teaching task includes experimental content and experimental plan design. Students first conduct online learning and chapter tests on the theoretical knowledge, and then submit the experimental design content to the instructor for review within the time frame specified by the instructor in conjunction with the teaching content. The experimental design content is submitted in the form of an innovative project.

(2) After the teacher has approved the experiment, students will conduct the experiment offline. In the experiment, every 4 students are a group. The technically difficult content in scientific research experiments, such as primer design is completed by the students under the guidance of the teacher, after the design is synthesized by the biological company, reagents or consumables are purchased by the students and the list of items is completed by the teacher.

(3) Students report and defend the research results, and put forward problems that cannot be solved by themselves in the research. The teacher makes comments, and combines the teaching content to summarize, expand and explain the doubts of the students.

(4) Teachers make an overall evaluation of the students' theoretical knowledge test and experimental research, and gives a staged evaluation result. Research results with scientific value are also affirmed, and students are guided to carry out the writing and publication of relevant papers.

(5) After students take the final test, Teachers summarize the grades of each phase and give each student a final evaluation grade for the semester. The final evaluation grade is 40% for the final exam, 10% each for the project application and thesis writing, 30% for the research process and results, and 10% for the usual test score.

2.3. Evaluation of Teaching Effect

The teaching and research department set up a proposition group to make propositions on the final exam papers. The proposition content requirements closely match the requirements of the syllabus, and the depth, breadth, difficulty, and layout of the test papers should be moderate; the proposition content should fully reflect the key and difficult points of teaching, and the content of the papers should basically cover all the contents required by the syllabus. After the final exam, the results of all students in the whole year will be summarized, and the reliability, validity, distinction and difficulty of the final exam paper will be analyzed. In the case that the overall quality of the test paper is reasonable, further statistical analysis was conducted by statistical t-test. Through statistical analysis, the effects of teaching in the new teaching mode and traditional teaching mode on students' performance were compared, and the possible role of teaching in the new teaching mode in improving students' literacy was analyzed through the differences in score of different question types.

3. RESULTS AND ANALYSIS

3.1. Overall Quality of Test Paper

645 students who participated in this final test had a maximum score of 91 and a minimum score of 27, with a full distance of 64 and a mean score of 64.08 ± 11.95 (Mean \pm Std, same below). Most of the students' score were

concentrated in the 50-80 score range, with the largest distribution of 60-65 score, accounting for 16.9% (Figure 1). The reliability of the test paper was 0.82. The test questions basically covered the content of the textbook. The difficulty coefficient of the test paper was 0.64, which was in line with the standard of the test paper. Some of the multiple-choice questions in the test paper had poor differentiation, with some of the 60 multiple-choice questions having a differentiation of 0.20 or less; short-answer and essay questions had a differentiation of 0.34 or more, and some of them reached 0.54 or more, which had good differentiation ability. From the perspective of the whole paper, the difficulty and differentiation of the multiple-choice questions need to be improved, while the short-answer and expository questions are of good quality.

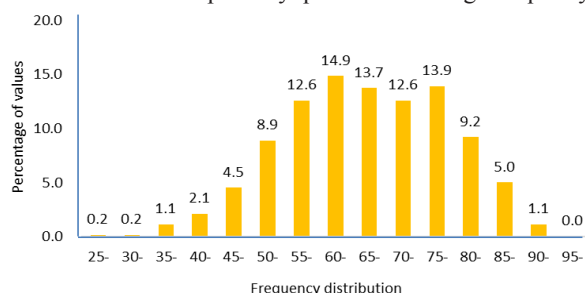


Figure 1. Frequency of overall distribution of score on student test papers

3.2. Evaluation of the teaching effect of the new teaching model

A total of 95 students were taught using the new teaching mode. During the teaching process, they successfully completed the teaching tasks through online and offline learning by combining the design of scientific research projects and the development of scientific practical research as well as the writing of papers. In the final exam, their average score was 64.3 ± 10.5 , which was not significantly different from 64.3 ± 12.2 of the students taught in the traditional teaching mode. Among them, their highest score was 91 and their lowest score was 39.5; most of the students's score were concentrated in the 50-80 score range. The overall distribution of score was consistent with the traditional teaching model and with the overall

distribution (Figures 2 and 3). There were three types of questions set in this test paper, namely multiple-choice, short-answer, and essay questions. Although overall there was no significant difference in students' score between the two teaching modes ($p > 0.05$), there was a difference between the two in terms of question types. This is reflected in the fact that there was no significant difference in students' score on multiple-choice and short-answer questions between the two teaching modes ($P > 0.05$), indicating that there was no significant effect of the two teaching modes on students' ability to answer these two types of questions ($P > 0.05$), but there was a significant difference in the score on essay questions ($P < 0.05$) (Table 1).

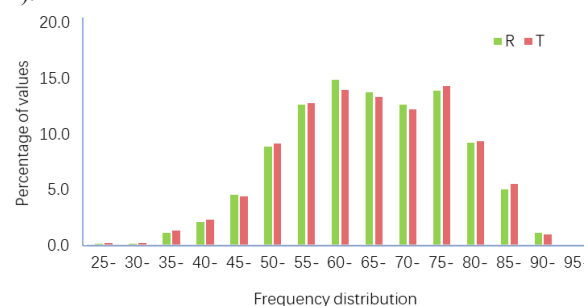


Figure 2. Frequency of distribution of final exam score under the research teaching model and traditional teaching model

Note: T, research teaching model; R, traditional teaching model

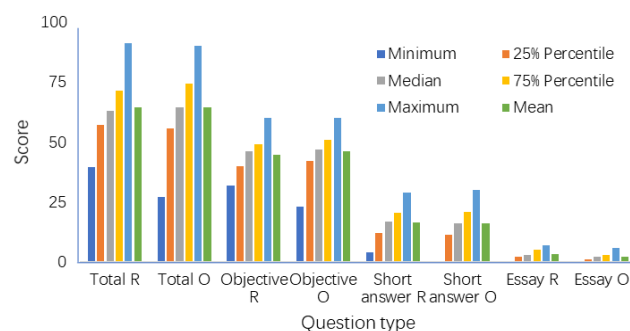


Figure 3. The distribution of students' final exam score using both the research teaching model and the traditional teaching model

Table 1. Two-tailed, unpaired t test of Score of diversity question type in research teaching model vs traditional teaching model

Question type	Total	Objective	Short answer	Essay	Subjective
<i>P</i>	0.998	0.066	0.626	<0.001*	0.058*
<i>t</i> (<i>df</i> =617)	0.003	1.839	0.487	6.318	1.898
Mean \pm SEM of R (<i>n</i> =95)	64.33 \pm 1.079	44.83 \pm 0.641	16.360 \pm 0.561	3.137 \pm 0.191	19.500 \pm 0.621
Mean \pm SEM of T (<i>n</i> =524)	64.33 \pm 0.533	46.21 \pm 0.298	16.050 \pm 0.258	2.077 \pm 0.0624	18.120 \pm 0.288
95% confidence interval	-2.616 to 2.622	-0.093 to 2.854	-1.596 to 0.961	-1.389 to -0.730	-2.802 to 0.048
<i>F</i> test	<i>F</i>	1.345	1.190	1.704	1.184
(<i>Dfn</i> =523, <i>Dfd</i> =94)	<i>P</i>	0.077	0.300	<0.001*	0.315

Note: T, research teaching model; R, traditional teaching model

* Refers to a statistically significant difference between the research teaching model and the traditional teaching model.

4. DISCUSSION

The scientific research-based classroom teaching model has been implemented in the teaching of a variety of course, and has achieved certain results, but the methods have their own merits. Wang et al. [12] introduced an instructional model on the molecular biology class that combined literature-based learning in experimental design for strengthening self-learning and scientific research skills of undergraduate medical students. Their method is similar to our teaching model this time. They also choose a topic first, and then students find and read literature in groups, design scientific experiments in groups, and then carry out experiments in laboratory courses. Hu et al. [13] believe that the theory and method of integrated innovation of design education have made significant contributions to the enhancement of the innovative and entrepreneurial ability of industrial design professionals. Evans et al. [14] think that the seven key skills, critical thinking, self-management, communication, information literacy, visual literacy, practical skills, and content knowledge are the context and quality which should be possessed by a biochemist. This also reflects from one aspect that the teaching of biochemistry should improve the scientific research literacy of students from these aspects.

We carried out the reform and practice of the research-based classroom teaching model in the undergraduate clinical medicine major at Youjiang Medical College for Nationalities in 2021. The results of the overall situation analysis of the test showed that the test papers had good reliability and validity and could be used as the material for this study. The overall score of the students' final exam showed no significant difference between the research-based classroom teaching model and the traditional teaching mode, indicating that research-based classroom teaching did not affect students' exam score. The distribution frequencies of students' score were also relatively consistent between the research-based classroom teaching model and the traditional teaching mode, indicating that the two teaching modes have similar effects on students' overall score. However, in terms of the score rates of different question types, they differed significantly in some aspects, which indicate that the two teaching models have differences in the development of answering ability for different question types.

Our paper questions consist of three types of questions: multiple-choice, short-answer, and essay questions. The first two questions mainly examine students' mastery of basic knowledge in books while the essay questions mainly examine students' understanding of events and cases as well as their analytical skills, logical thinking, scientific thinking and written expression. When answering essay questions, students must make scientific judgments and describe their arguments. This argumentative process better reflects students' level of scientific and theoretical literacy and mindset, as well as their ability to use professional language to explain their views and solve problems. Therefore, essay questions can best reflect the students' the level of expertise. In our teaching reform practice, students

taught by the research-based classroom model scored significantly higher on the essay questions than those taught by the traditional teaching model, which indicates that teaching in the research-based classroom model can effectively cultivate students' scientific literacy and improve their professional knowledge, especially their analytical skills, logical thinking, scientific thinking, and writing. The results of our analysis showed that there was no significant difference in the multiple-choice and short-answer score of students taught by the two teaching modes, indicating that the research-based classroom teaching mode does not have an advantage over the traditional teaching mode in terms of basic knowledge learning.

There are many factors involved in the development of research literacy, such as teachers' conceptions of teaching, students' conceptions of learning, teachers' literacy levels, students' basic levels, teaching platforms, various aspects of teaching practice, the effectiveness of teaching evaluation tools, students' spare time, etc [15-16]. Each of these factors may play an important role in the effectiveness of research literacy development. In addition, in the context of the COVID-19 pandemic, online teaching has become an important teaching tool, so the appropriate online learning mode is also an important aspect that affects students' learning efficiency and the effectiveness of their research literacy development. In order to promote more effective training, scholars in China and abroad have conducted a lot of research and practice on the ways to develop students' research literacy. The research-based classroom model we have implemented is to some extent more effective in developing and improving students' research literacy and their ability to use professional knowledge to analyze and solve problems and to conduct logical reasoning. However, the new teaching model did not significantly improve the learning effect of basic knowledge. The main reason for this result may be that the implementation of the research-based teaching mode takes up more learning time, which reduces the time for students to learn and memorize basic knowledge. Thus affecting the learning effect of students' basic knowledge. In addition, the effectiveness of online learning before class may not be well guaranteed, the monitoring methods for learning basic knowledge before class are not in place, and the evaluation after learning does not effectively play the role of supervising and testing the theoretical knowledge of students' self-learning of books. There is also a relatively boring basic knowledge, students' learning motivation is not enough, and so on. This is also an aspect that we need to further improve and strengthen in the future. In addition, the evaluation method and the proportion of points, the final exam score are set to account for a low proportion of 40%, which may also cause the final exam to not effectively play the role of promoting students to review the teaching content systematically. Furthermore, the implementation of the research-based classroom teaching mode in biochemistry and molecular biology has only been implemented for one semester, which is still a short period of time, and some of the cultivation effects will be slow to emerge, so we still need to carry out several practices in

order to identify problems and improve and optimize the teaching process.

5. CONCLUSION

Overall, the research-based classroom model was able to develop and improve students' research literacy as well as provide them with the ability to use their expertise to analyze and solve problems and to make logical reasoning. Although its failure to effectively promote students' learning of basic knowledge, it did not affect the efficiency of students' learning of basic knowledge.

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