

Exploration and Practice of OAO Teaching Mode for Biomedical Engineering under the Background of Normalize Epidemic Prevention and Control

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Abstract: Objective In order to meet the needs of the normalization of epidemic prevention and control, the modern information technology-based OAO teaching mode was adopted in some courses of biomedical engineering. To explore the application value of OAO teaching mode in biomedical engineering. **Methods** A comparative investigation on the reform of OAO teaching mode was carried out with two years of students majoring in biomedical engineering as research objects, and statistical analysis was conducted on the data obtained from the investigation. **Results** By comparing the effect before and after the implementation of OAO teaching mode, it is confirmed that the final paper examination score of Principles & Techniques of Medical Ultrasound were improved after the implementation of OAO teaching mode ($t=-2.014$; $P<0.05$), the both paper scores of Medical Imaging and Principle & Design of Medical Devices were significantly improved ($t=-3.254$, $t=-2.803$; $P < 0.01$). The number of students with complete experimental design, skilled experimental operation and good experimental report increased in the experimental hours of medical device courses ($2=5.316$, $2=5.828$, $2=5.741$; $P < 0.05$). The teaching evaluation questionnaire survey shows that 96.7% of students were satisfied with the OAO teaching mode, 91.1% of students were satisfied with the overall mastery of the courses, and the overall course satisfaction reached 95.5%. **Conclusions** OAO teaching mode is not only a teaching mode reform measure in response to the normalization of epidemic prevention and control, but also in line with the development requirements of the Ministry of Education on the construction of new engineering. It can make full use of the complementary advantages of online and offline teaching to improve the teaching quality and has high value of teaching application and promotion.

1. Introduction

Biomedical engineering is an interdisciplinary discipline that requires students to master computer science, electronics, medicine, biology, materials science and other disciplines. It is a key development direction of interdisciplinary specialty to cultivate senior engineers and technicians with the ability to solve clinical medical problems with engineering thinking [1]. In the context of the continuous development of information technology, the construction and development of new engineering have more emphasis on the comprehensiveness, practicability and intersectionality of discipline cultivation, and the disciplinary characteristics of biomedical engineering coincide with the construction ideas of new engineering [2]. As the affiliated hospital of a university directly under the Ministry of Education, a large grade-a general hospital in Xi 'an has carried out multi-disciplinary joint training with the university, and biomedical engineering has been constructed as a key joint teaching major.

Since the outbreak of COVID-19 at the end of 2019, China's epidemic prevention and control work has timely and effectively blocked the large-scale spread of the epidemic in China. However, due to the continuous spread of the epidemic in other countries and regions around the world, China has been under increasing pressure to prevent imported COVID-19. Normalization of epidemic prevention and control has become an important measure to protect people's lives and health [3]. Since 2020, the teaching teams of the hospital and its affiliated universities have actively coordinated and communicated with each other. After many investigations and innovations, they jointly determined the "Online and Offline Hybrid Teaching Mode (OAO teaching mode)" for biomedical engineering specialty. This method can make full use of the advantages of modern highly developed information and communication technology. It can reduce the number of mass movement of students between the school and the hospital, and reduce the chance of students being infected when there is a high risk of epidemic. At the same time, OAO teaching mode can also make full use of the respective advantages of online and offline teaching, it can improve teaching quality and efficiency, and reduce teaching costs. It is a new idea of teaching reform and development. This paper evaluates and studies the effect of implementing OAO teaching mode.

2. Research materials and methods

2.1. Research materials

The undergraduate students of grade 2020 majoring in biomedical engineering in this university were selected as the research objects. The students in this grade have been learning by OAO teaching mode since February 2021.

2.2. Research methods

2.2.1. The construction of OAO teaching mode

OAO teaching mode is divided into online and offline teaching, forming a situation of complementary advantages of online and offline teaching mode.

1) Teaching preparation stage

According to the teaching syllabus of medical device courses, the teaching knowledge points were sorted out. Micro-class videos were filmed for the parts that need to be demonstrated in detail in the corresponding departments of medical devices in the hospital, which are explained in micro-lectures by the senior professional staff with teacher qualifications in the hospital. For the parts that need to be explained in theory, micro-class videos were made by the corresponding professional

course teachers in the university. After 8 months of preparation, a total of 165 on-site explanation videos of medical devices were recorded, and 230 theoretical explanation videos of medical devices were recorded. All the micro-class videos were accepted by the Teaching Affairs Office of the university and the Teaching Office of the hospital and they were allowed to enter the micro-class teaching courses resource library of the university, and at the same time, the learning task list and synchronous PPT of each class were made for students' independent learning.

2) Online teaching process

The online teaching part of the teaching implementation process was carried out through the Yuketang network learning platform. All recorded micro-classes were uploaded to the learning platform of Yuketang. Students could log in to Yuketang on PC or mobile phone for independent learning according to the specified time period of the class schedules. Before each class, there was a learning task list and PPT for simultaneous learning and recording of knowledge points. In each class, class check-in and timed test exercises were set to supervise autonomous learning and ensure the quality of classroom learning. After each class, homework was pushed to consolidate learning achievements. If students could not understand the knowledge points during learning, they would repeatedly watch the micro-class video explanation at any time within a certain period of time. Students could also discuss with teachers and classmates in the wechat course groups to pool wisdom and divergent thinking, so as to integrate knowledge points and further improve students' interest and ability in autonomous learning. At the same time, the course teachers could also enter the Yuketang at any time to check the online learning situations of students including the check-in situations and in-class test situations, correct the homework after classes, and summarize the common and individual problems found after in-class tests or after-class homework corrections.

Offline teaching process

After the online teaching progress of each chapter was completed according to the specified time, an offline classroom theoretical teaching would be conducted in the classroom of the main campus of the university. In offline classroom teaching, course teachers summarized the contents of the whole chapters and explained the common and individual problems encountered in online in-class tests and homework so that students could effectively "absorb and internalize" the contents of the whole chapters, which is also called flipped classroom teaching [4]. In addition, according to the content characteristics of each chapter, the course teachers could arrange relevant topics that could deepen students' understanding and application of the chapter contents, and let students discuss in groups to design innovative and achievable project plans. Meanwhile, the teachers walked back and forth between groups, listening to the discussion process within the groups, and participated in the discussion appropriately, and gave suggestions. Finally, each group would form a complete project plan, which would be presented in class. Teachers and students would explore the innovation and shortcomings of each plan together in class. The whole process of offline classroom theoretical teaching not only completed the knowledge sorting and internalization of the whole chapters, but also exercised students' knowledge application ability, dialectical thinking ability, classroom presentation ability and teamwork ability.

In online micro-class learning, students had a certain degree of concrete understanding of the structure, principle and operation of medical devices. At the same time, in offline flipped classroom teaching, teachers had timely improved and guided students' project design methods, which had improved students' overall experimental design ability and knowledge transformation ability. Therefore, in the process of offline experimental classes, more students could complete independent experimental operations more quickly, and some students had gained the ability to independently design and complete higher-order experimental schemes. In addition, group discussions in offline classes also exercised students' ability of division of labor and cooperation. For experimental courses that need to be completed by teams, students would actively discuss and cooperate in an

orderly manner, and would be able to design more mature experimental schemes that met the requirements.

On the other hand, the OAO teaching mode could reduce the number of mass movement of students between the school and the hospital, and the number of offline class hours in the main campus had been also greatly reduced, which helped to reduce the risk of epidemic transmission under the situation of normalized epidemic prevention and control [5]. Table 1 shows the change of offline class hours before and after the teaching mode reform.

Table 1: Comparison of offline teaching hours before and after the teaching mode reform of medical devices

| Course name | Original teaching mode | | | OAO teaching mode | | |
|---|------------------------------------|-------------------------------------|------------------------------|------------------------------------|-------------------------------------|------------------------------|
| | Offline theoretical teaching hours | Offline experimental teaching hours | Offline total teaching hours | Offline theoretical teaching hours | Offline experimental teaching hours | Offline total teaching hours |
| Medical Imaging | 32 | 8 | 40 | 16 | 8 | 24 |
| Principle & Design of Medical Devices | 52 | 32 | 84 | 30 | 26 | 56 |
| Principles & Techniques of Medical Ultrasound | 26 | 6 | 32 | 14 | 6 | 20 |

2.2.2. Teaching evaluations

Table 2: Teaching evaluation criteria for medical device courses in OAO teaching mode

| Evaluation method | Online/Offline | Evaluation indicators | Evaluation basis | Proportion (%) |
|---------------------------|----------------|----------------------------------|----------------------|----------------|
| Diagnostic evaluations | Online | Check-in | Data of the Yuketang | 2.5 |
| | | Completion rate of micro classes | | 10 |
| | | Pre-class test | | 5 |
| | Offline | Check-in | Teaching records | 2.5 |
| Formative evaluations | Online | Time-limited test | Data of the Yuketang | 10 |
| | | Homework | | 15 |
| | Offline | Class performance | Teaching records | 5 |
| Experiment implementation | 10 | | | |
| Summative evaluations | Offline | Final exam | Paper tests | 40 |
| Total | | | | 100 |

Teaching evaluations are processes in which scientific evaluation criteria are formulated according to teaching objectives through careful and rigorous research and the results of teaching activities are measured by various technical means [6]. Teaching evaluations run through the learning processes of the whole courses, including diagnostic evaluations, formative evaluations and summative evaluations. The diagnostic evaluations and formative evaluations of online

teaching process mainly rely on classroom data of the teaching platform of Yuketang, including check-in, pre-class test, time-limited test and completion of homework, etc. Meanwhile, the diagnostic evaluations and formative evaluations of offline teaching process mainly depend on class attendance, class performance, experiment implementation, etc. And the examinations at the end of the semesters are the main form of summative evaluation [7,8].

2.2.3. Implementation effect comparison schemes of OAO teaching mode

1) Comparison of final exam results of medical device courses

The OAO teaching mode has been implemented for undergraduates majoring in biomedical engineering of grade 2020 since February 2021. In the final exam in July 2021, the same exam paper as grade 2019 was used for medical device courses, which was strictly confidential to grade 2020 students for one year before the exam. After the exam results came out, 50 students from the class of 2020 and the class of 2019 were randomly selected to compare their scores.

2) Comparison of experimental teaching hours evaluations of medical device courses

Statistics were made on the evaluation of the experimental hours of the three device courses of 50 randomly selected students in grade 2020 in 3.1.1, including the number of students with complete experimental design, the number of students with skilled experimental operation and the number of students with good experimental reports (more than 80 points). Comparison was made with the teaching records of 50 students in grade 2019 selected in 3.1.1.

Teaching evaluation questionnaire survey

Likert5 scale was used to conduct a questionnaire survey on teaching evaluation of 93 biomedical engineering students in grade 2020, which included the evaluation of teaching methods, learning methods and overall course satisfaction.

2.2.4. Statistical analysis method

SPSS20.0 software was used for statistical analysis of 3.1.1 and 3.1.2 comparison data, in which the test results were measured data, expressed by $(\bar{x} \pm s)$, and analyzed by T test. The average number of students in the evaluation of the experimental hours was counted as counting data, represented by the number of students and percentage (n (%)), and analyzed by the Chi-square test. $P < 0.05$ indicated statistical difference, and $P < 0.01$ indicated significant statistical difference. At the same time, the satisfaction of the questionnaire survey in 3.1.3 was recorded and counted.

3. Results

3.1. Comparison of final paper exam results of medical device courses

Table 3: Comparison of final paper exam results of students in two grades before and after the implementation of OAO teaching mode (score, $\bar{x} \pm s$)

| Grade | Medical Imaging | Principle & Design of Medical Devices | Principles & Techniques of Medical Ultrasound |
|----------|------------------|---------------------------------------|---|
| 2019 | 79.87 \pm 8.22 | 81.52 \pm 8.75 | 80.91 \pm 8.69 |
| 2020 | 83.61 \pm 6.67 | 86.14 \pm 7.23 | 85.34 \pm 7.48 |
| <i>t</i> | -3.254 | -2.803 | -2.014 |
| <i>P</i> | 0.002 | 0.006 | 0.047 |

Table 3 shows the comparison of final paper exam results of medical device courses of the two grades students before and after the implementation of OAO teaching mode. After the implementation of OAO teaching mode, the final paper exam score of Principles & Techniques of

Medical Ultrasound were improved ($t=-2.014$; $P<0.05$), the both paper scores of Medical Imaging and Principle & Design of Medical Devices were significantly improved ($T = -3.254$, $T = -2.803$; $P < 0.01$).

3.2. Comparison of experimental teaching hours evaluation results of medical device courses

Table 4 shows the comparison of experimental teaching hours evaluation results of medical device courses between the two grades students before and after the implementation of OAO teaching mode. After the implementation of OAO teaching mode, the number of students with complete experimental design, skilled experimental operation and good experimental report increased in the experimental hours of medical device courses ($\chi^2=5.316$, $\chi^2=5.828$, $\chi^2 = 5.741$; $P < 0.05$).

Table 4: Comparative analysis of experimental hours of medical device courses[num,n(%)]

| Group | Number of students | Complete experimental design | Skilled experimental operation | Good experimental report |
|----------|--------------------|------------------------------|--------------------------------|--------------------------|
| Before | 50 | 39(78.0) | 34(68.0) | 37(74.0) |
| After | 50 | 47(94.0) | 44(88.0) | 46(92.0) |
| χ^2 | - | 5.316 | 5.828 | 5.741 |
| P | - | 0.021 | 0.016 | 0.017 |

3.3. The results of teaching evaluation questionnaire survey

A total of 93 questionnaires were sent out in this study, and 90 were effectively collected. The statistical results are shown in Table 5 below. The teaching evaluation questionnaire survey shows that 96.7% of students were satisfied with the OAO teaching mode, 91.1% of students were satisfied with the overall mastery of the courses, and the overall course satisfaction reaches 95.5%.

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Table 5: Statistical table of teaching evaluation questionnaire survey results[n=90,(n%)]

| Item | Very/relatively satisfied | Moderately satisfied | Relatively/very dissatisfied |
|--------------------------------|---------------------------|----------------------|------------------------------|
| Online courses | 76(84.4) | 10(11.1) | 4(4.5) |
| Offline courses | 69(76.6) | 16(17.8) | 5(5.6) |
| Experimental courses | 67(74.4) | 18(20.0) | 5(5.6) |
| Autonomous learning | 73(81.1) | 11(12.2) | 6(6.7) |
| Group learning | 69(76.7) | 14(15.6) | 7(7.8) |
| OAO teaching mode | 79(87.8) | 8(8.9) | 3(3.3) |
| Overall mastery of the courses | 66(73.3) | 16(17.8) | 8(8.9) |
| Overall course satisfaction | 78(86.6) | 8(8.9) | 4(4.5) |

4. Discussion

The construction of "new engineering" is an important measure for China to adapt to the industrial reform in the new era. Compared with traditional engineering, new engineering emphasizes to create interdisciplinary talents with global vision, innovation ability and

multidisciplinary knowledge through multi-dimensional training, so as to respond to major strategic decisions and deployment such as "One Belt and One Road" and "Made in China 2025", and realize the guidance and support for emerging industries. Biomedical engineering, as a highly integrated discipline of medicine and engineering, emphasizes on solving clinical problems through engineering technology, and is the key development discipline of "new engineering" in the cross-medical field. In order to meet the requirements of "new engineering" talents training, it is necessary for the teaching and research personnel of biomedical engineering specialty to conduct in-depth research and exploration in the reform of teaching mode [9]. On the other hand, in the past two years, the international COVID-19 situation has been grim, and it is very important to ensure the health and safety of the Chinese people to normalize the epidemic prevention and control measures at home. It is a difficult problem for professional teachers to complete the teaching task of professional courses with quality and quantity guaranteed while ensuring the prevention and control of the epidemic.

Under the background of the normalization of epidemic prevention and control, in order to meet the development needs of "new engineering" construction, the teaching team of the hospital and affiliated universities actively explored the use of OAO teaching mode in some courses of biomedical engineering. This teaching mode can make full use of information technology to realize the deep integration of online and offline education, and it can also cultivate students' divergent thinking habits and the ability of multi-dimensional exploration and practice to solve problems.

In the comparison of the implementation effects of teaching modes, the theoretical knowledge level of students were greatly improved due to the fact that in the online teaching process, students had acquired a concrete understanding of the principle, structure and operation of medical devices through micro-class learning, and consolidated conceptual understanding through pre-class tests and time-limited tests, and teachers patiently answered questions and explained in the offline classroom teaching process. As a result, the final exam scores of medical device courses were improved compared with those before the teaching reform. At the same time, students had greatly improved the experimental implementation skills, and achieved good results in the evaluation of experimental hours through group discussion, lecture and other forms to master the methods and ideas of the topic and experiment design in the offline class learning.

In the process of OAO teaching mode, the online teaching had vivid display of medical devices, and the offline class time had been greatly reduced. Meanwhile, the original stylized offline classroom teaching method was changed, and students were encouraged to study independently. Questions were set in classes for students to discuss, explore and make speeches, which enriched teaching methods. In the relaxed and pleasant learning process, students' learning enthusiasm was greatly improved, and a good competitive atmosphere was formed, which made students' satisfaction with the OAO teaching mode and the courses very high, and students had a good mastery of the course knowledge.

5. Conclusions

OAO teaching mode is not only a teaching mode reform measure in response to the normalization of epidemic prevention and control, but also in line with the development requirements of the Ministry of Education on the construction of new engineering. It can make full use of the complementary advantages of online and offline teaching, mobilize students' independent learning ability, stimulate students' innovative thinking, and realize the improvement of teaching quality. OAO teaching mode is a new idea of teaching reform and development, which has a high value of teaching application and popularization.

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