

Research on the Application Effect of Four-Track Teaching Method in the Hospital Internship of Biomedical Engineering Based on Bonfferoni and LSD Test Analysis

Qianyu Zhang¹, Qinfeng Liu^{2,*}, Hui Liu², Shuanglin Wei², Tao Wang³

¹School of Life Science and Technology, Xi 'an Jiaotong University, Xi'an, Shaanxi, 710049, China

²Medical Equipment Management Department, Shaanxi Provincial People's Hospital, Xi'an, Shaanxi, 710068, China

³Department of Medical Imaging, Hospital of Stomatology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710004, China

*Corresponding author: 420769943@qq.com

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Abstract: **Objective** To explore the application value of LBL-CBL-PBL-TBL four-track teaching method in the hospital intership of biomedical engineering. **Methods** The students majoring in biomedical engineering who had been interning in the hospital from March to June 2021 were divided into three groups: A, B and C. LBL-CBL, LBL-CBL-PBL and LBL-CBL-PBL-TBL teaching methods were adopted respectively. Before the end of the internship, the students' internship situation and teaching satisfaction were investigated and statistically analyzed, and the Bonfferoni and LSD tests were used for multiple comparative analysis between groups. **Results** In the comparison of basic theory test scores and total scores, groups B and C were higher than group A, group C had the highest score ($F=24.648, F=35.518; P < 0.001$), the scores of groups B and C were also higher than that of group A ($F=19.317; P < 0.001$), and there was no significant difference between the scores of group B and group C ($P=0.101 > 0.05$); in the statistics of students internship grading by the the internship guide teachers, the scores of the students' learning enthusiasm and innovative practice ability of groups B and C was better than that of group A, and group C had the best performance ($F=84.312, F=65.324; P < 0.001$), students in group C scored better than those in groups A and B ($F=56.116; P < 0.001$), and there was no significant difference between groups A and B in teamwork ability scores ($P=0.410 > 0.05$); in the statistics of student questionnaire survey grading, students in groups B and C were better than group A in teaching mode satisfaction, internship skills and medical engineering thinking, and group C had the best performance ($F=76.318, F=45.589, F=145.473; P < 0.001$). **Conclusions** LBL-CBL-PBL-TBL four-track teaching method can enhance students' learning enthusiasm, improve their comprehensive ability level and improve their mastery of practice skills in the process of internship of biomedical engineering, which has high application and promotion value.

1. Introduction

In recent years, with new technologies, new economy and the rapid development of new industries, China's Ministry of Education puts forward the development direction of new engineering construction. Compared with traditional engineering education, "New Engineering Education" pays more attention to the comprehensiveness, practicability and intersectionality of discipline construction and the improvement of students' innovation ability, practical ability and collaboration ability, aiming to cultivate interdisciplinary high-quality talents with interdisciplinary application ability [1]. Biomedical engineering is a discipline with obvious characteristics of "new engineering". How to cultivate high-quality talents with basic knowledge of computer and electronic engineering as well as basic knowledge of clinical medicine to solve technical problems of medical engineering is an urgent demand for the development of biomedical engineering under the new situation [2]. In the teaching system structure of biomedical engineering, internship is an important way for students to master the principle, operation and management methods of medical instruments and equipment, and an important part of undergraduate teaching and training. Therefore, it is imperative to explore a biomedical engineering internship mode that meets the needs of the construction and development of "new engineering" [3].

A large hospital in Xi'an, Shaanxi Province, China, as a teaching hospital of colleges and universities, explored the application of LBL-CBL-PBL-TBL four-track teaching method in the internship teaching of biomedical engineering specialty. The teaching method organically combines LBL, CBL, PBL and TBL commonly used in medical higher teaching at home and abroad to stimulate students' interest in learning, deepen their understanding of medical engineering knowledge, and improve their innovation consciousness, hands-on ability and teamwork ability [4]. This study is to compare the effect of the four-track teaching method with that of the traditional teaching method, in order to verify the promotion effect of the four-track teaching method on improving teaching quality, so as to provide demonstration suggestions for the teaching mode reform of other majors.

LBL (Lecture-Based Learning) teaching method is based on textbooks and handouts. In the teaching process, teachers lead the systematic and comprehensive explanation of subject theoretical knowledge, and carries on the indoctrination teaching. This method can comprehensively explain the knowledge framework according to the teaching schedule [5], but it is not enough to mobilize students' learning enthusiasm.

CBL (Case-Based Learning) teaching method is a typical case-oriented teaching mode, which was first proposed in the reform of higher medical education in China. It is a teaching method that organizes students to study and discuss some typical cases under the guidance of teachers. It extends the teaching content of abstract theories into specific clinical cases. It extends the abstract theoretical teaching content to specific clinical cases, and guides students to participate in the analysis and discussion. With cases as the guide and students as the main body, it deepens and concretizes the theoretical teaching content, which can consolidate the theoretical knowledge of the subject and mobilize students' learning enthusiasm [6].

PBL (Problem-Based Learning) teaching method is a problem-oriented teaching mode, which was proposed by Barrows, a famous Neurology professor in the United States in 1969. It takes problems as a starting point and guides students to study and explore based on problems. In the process of solving problems, students have a deeper understanding of relevant theoretical knowledge, which can exercise their independent learning ability and inspire students to solve problems [7].

TBL (Team-based Learning) teaching method is a team-collaborative oriented teaching mode, which was proposed by the American scientist Michaelsen LK in 2002. It is based on teamwork,

and students are given sufficient time and space to discuss, communicate and learn from each other in groups during the teaching process. Finally, learning tasks can be completed under the guidance of teachers, which can cultivate students' independent learning ability, communication ability and teamwork consciousness [8,9].

2. Materials and methods

2.1. General materials

A total of 97 undergraduate students majoring in biomedical engineering who had been interning in the hospital from March to June 2021 were selected, including 63 female students and 34 male students. They were randomly divided into three groups A, B and C, including 32 in group A, 32 in group B and 33 in group C. There was no statistically significant difference in the ratio of male to female, average age and average score before practice in each group.

2.2. Methods

For group A, the traditional teaching method of LBL-CBL was implemented. The internship teachers carried out theoretical teaching of relevant courses of biomedical engineering according to the requirements of the internship outline, textbooks and handouts, and carried out on-site practice. With typical cases needing attention and the common failures encountered in the operation of medical equipment as the starting point, the practice teacher guided students to draw out the final solutions to the problems combining with theoretical knowledge and principles.

For group B, LBL-CBL-PBL teaching method was implemented. Based on the teaching method of group A, the internship teachers introduced some medical engineering problems and guided the students to think independently. Comprehensive analysis was conducted by using multidisciplinary knowledge such as physics, chemistry, material science, biology and computer science. Experiments were designed independently and various experimental schemes were finally obtained. Teachers commented on each experimental scheme and selected some optimal schemes for students to learn from each other.

For group C, LBL-CBL-PBL-TBL four-track teaching method was implemented. On the basis of the teaching method of group B, some comprehensive medical engineering projects were developed. The students discussed in groups, and the project plan was designed by the group as a unit. The teacher walked back and forth between groups, listened to the discussion content of each group and gave timely guidance. Finally, each group reported the design scheme of each subject in the form of PPT. Students and teachers analyzed and discussed the advantages and disadvantages of each scheme and proposed improvement methods.

2.3. Evaluation of teaching effect

2.3.1. Comparison of test results

Students were assessed at the end of the internship. The full score is 100, the basic theory test and the practical skills test each account for 50%. While the basic theory test adopts paper-based test method, and the practical operation skill test adopts on-site operation method. Three clinical medical engineering experts with senior titles in the hospital were invited to score the practical operation skill of the same students on the spot. The students' practical skills test scores were the average scores given by the three experts. The statistical results of A/B/C group were analyzed.

2.3.2. Teachers' evaluation of students' internship

Before the end of the internship, the teachers scored the internship situation of each student. The scoring items include students' learning enthusiasm, independent learning ability, innovation and practice ability and teamwork ability, with a full score of 10 points for each item, with 0-2 being poor, 2-4 being poor, 4-6 being medium, 6-8 being good and 8-10 being excellent.

2.3.3. Questionnaire survey of students

Before the end of the internship, a questionnaire survey was conducted on the students, including four items of the teaching level of the teachers, teaching mode, internship skills mastery and medical engineering thinking establishment. The full score for each item was 10 points, with 0-2 being poor, 2-4 being poor, 4-6 being medium, 6-8 being good and 8-10 being excellent.

2.4. Statistical analysis

SPSS20.0 software was used for statistical analysis. Normality test was carried out for each group of data, and normality was represented by ($\bar{x} \pm s$). Homogeneity test of variance was conducted for the three groups of comparison data in each item. According to the test results, the corresponding method was used for one-way analysis of variance, and $P < 0.05$ indicated that the difference was statistically significant.

3. Results

3.1. Comparison of examination results

Statistical analysis results of students' basic theory test, practical operation skill test and total test scores before the end of internship are shown in Table 1. It can be concluded that the results of the basic theory test, practical operation skill test and total test scores of the students of ABC three groups conform to the normal distribution. The pairwise comparison results of ABC three groups in each result were verified to meet the homogeneity of variance ($P > 0.05$). Bonfferoni test was used for multiple comparison between groups. The results showed that in the comparison of basic theory test and total scores, the scores of groups B and C were higher than those of group A, and group C had the highest scores, with statistically significant differences ($F=24.648, F=35.518; P < 0.001$); in the comparison of practical operation skill test, the scores of groups B and C were also higher than those of group A, and the differences were statistically significant ($F=19.317; P < 0.001$), there was no significant difference between groups B and C ($P=0.101 > 0.05$).

Table 1: Statistical analysis table of internship students' test scores (Score, $\bar{x} \pm s$)

Group	n	Basic theory test	Practical operation skill test	Total test score
A	32	38.64 \pm 3.65	38.16 \pm 4.21	76.80 \pm 5.70
B	32	42.20 \pm 3.54	41.80 \pm 3.56	84.00 \pm 5.64
C	33	44.60 \pm 3.12	43.77 \pm 3.25	88.38 \pm 5.41
<i>F</i>	-	24.648	19.317	35.518
<i>P</i>	-	0.000	0.000	0.000

3.2. Evaluation results of students' internship by teachers

The statistical analysis results of each student's internship situation scored by the teachers before the end of the internship are shown in Table 2 below. It can be concluded that 12 groups of scoring data of learning enthusiasm, autonomous learning ability, innovative practice ability and team cooperation ability of students of the ABC three groups conform to the normal distribution. The pairwise comparison results of ABC three groups in each result were verified to meet homogeneity of variance ($P > 0.05$). LSD test was used for multiple comparison between groups. The results showed that students in groups B and C were better than those in group A in learning enthusiasm and innovative practice ability, and group C had the best performance, the difference was statistically significant ($F=84.312, F=65.324; P < 0.001$); students in group C were scored better on teamwork ability than those in groups A and B, and the difference was statistically significant ($F=56.116; P < 0.001$); there was no significant difference in scores of teamwork ability between groups A and B ($P=0.410 > 0.05$), and there was no statistical significance in scores of autonomous learning ability between groups ($P=0.265 > 0.05$).

Table 2: Statistical analysis table of students' internship score (Score, $\bar{x} \pm s$)

Group	n	Learning enthusiasm	Autonomous learning ability	Innovative practice ability	Teamwork ability
A	32	5.56±0.57	6.46±0.34	5.53±0.30	5.56±0.20
B	32	6.27±0.41	6.41±0.39	6.23±0.25	5.49±0.35
C	33	7.22±0.55	6.55±0.25	6.46±0.43	6.21±0.34
<i>F</i>	-	84.312	1.349	65.324	56.116
<i>P</i>	-	0.000	0.265	0.000	0.000

3.3. Results of student questionnaire survey

Statistical analysis results of questionnaire survey for each student before the end of internship are shown in Table 3. It can be concluded that the 12 groups of scoring data of the three ABC groups' satisfaction with internship teachers' teaching level, satisfaction with teaching mode, mastery of internship skills and establishment of medical engineering thinking are all in line with normal distribution. The pairwise comparison results of the three ABC groups in each score were proved to meet the homogeneity of variance ($P > 0.05$). LSD test was used for multiple comparisons between groups. The results showed that students in groups B and C were better than group A in teaching mode satisfaction, internship skills and medical engineering thinking, and group C was the best, with statistically significant differences ($F=76.318, F=45.589, F=145.473; P < 0.001$), and there was no statistical significance in the multiple comparison between groups of students' satisfaction scores on teaching level of internship teachers ($P=0.484 > 0.05$).

Table 3: Statistical analysis table of students' questionnaire score (Score, $\bar{x} \pm s$)

Group	n	Teaching level satisfaction	Teaching model satisfaction	Mastery of internship skills	Medical engineering thinking
A	32	8.66±0.27	7.78±0.34	8.31±0.38	7.84±0.22
B	32	8.61±0.23	8.26±0.23	8.80±0.24	8.41±0.26
C	33	8.60±0.18	8.64±0.26	9.09±0.34	8.87±0.24
<i>F</i>	-	0.732	76.318	45.589	145.473
<i>P</i>	-	0.484	0.000	0.000	0.000

4. Discussion

In recent years, with the advent of new scientific and technological revolution and the development of emerging industries, the demand for new engineering talents is more urgent. In this context, the Ministry of Education of China calls on colleges and universities to carry out research on the construction of new engineering, promote the reform and exploration of engineering education model, encourage interdisciplinary integration, and continuously supply talents with new qualities, new knowledge and new methods with sustainable competitiveness for the development of relevant industries and disciplines. The construction of new engineering sets off a new wave of reform in the development of higher education in China [10-12]. Biomedical engineering is a highly integrated major of medicine and engineering. According to the requirements of Biomedical Engineering Teaching Steering Committee of the Ministry of Education, students of this major should not only master the basic theoretical knowledge of the discipline, but also have the ability to comprehensively analyze and solve complex medical engineering problems with multidisciplinary knowledge, emphasizing the cultivation of students' innovative and practical ability [13]. The talent training goal of biomedical engineering is highly consistent with the requirements of new engineering construction, and the proposal of new engineering, a major strategic decision of engineering education reform in colleges and universities, stimulates the continuous innovation and improvement of the teaching mode of this major [14].

LBL-CBL teaching method is often used in the traditional internship teaching of biomedical engineering. In this internship teaching mode, teachers are guided to teach theoretical knowledge in accordance with the requirements of the internship syllabus, supplemented by some case-based teaching. This method can comprehensively and systematically impart theoretical knowledge, and explain some medical equipment management knowledge and solutions to common equipment failures. However, this method is dominated by textbooks and cases, and provides indoctrination-style education to students. It is difficult to motivate students' learning enthusiasm, and lack of cultivation of students' innovative practical ability and shaping of medical engineering thinking [15]. In order to respond to the strategy of strengthening higher education of the Ministry of Education, promote the construction of new engineering, and solve a series of practical problems summed up in the internship teaching of biomedical engineering, the teaching and research staff of universities and hospitals jointly studied the LBL-CBL-PBL-TBL four-track teaching method. In order to verify the effectiveness of the proposed internship teaching method, multiple comparisons were made in this study between this teaching method and the traditional LBL-CBL teaching method and the LBL-CBL-PBL three-track teaching method, which is often mentioned in the teaching reform mode.

4.1. LBL-CBL-PBL-TBL four-track internship teaching method can mobilize students' learning enthusiasm.

In the four-track teaching method, it is no longer dominated by passive indoctrination-oriented teaching, but student-centered. Some practical medical engineering problems that students are interested in are introduced into PBL teaching mode, which effectively improves students' learning enthusiasm. At the same time, in the group discussion of the subject under TBL teaching mode, each member of the group also competently participates. A competitive learning atmosphere is formed, and students' learning enthusiasm is fully mobilized [16]. According to the results of the evaluation of students' internship by the teachers, since the LBL-CBL-PBL mode was also adopted in the internship teaching process, the students in group C of the four-track teaching method and group B of the three-track teaching method were more active in learning than those in group A of the traditional teaching method, and the TBL mode of group C was also helpful in improving their learning enthusiasm. Therefore, group C of the four-track internship teaching method had the

highest learning enthusiasm. At the same time, the students in group C learned actively and had a deeper understanding of theoretical knowledge in the internship learning process, so that the scores of the basic theory test in group C were significantly higher than those in groups A and B.

4.2. LBL-CBL-PBL-TBL four-track internship teaching method can improve students' innovative practice ability and teamwork ability, and help students establish medical engineering thinking.

In the four-track internship teaching method, because the PBL teaching mode is adopted in combination, the teachers guide students to divergent thinking, analyze from multiple perspectives, and comprehensively apply multidisciplinary knowledge to solve problems. In this process, teachers raise questions, students consult materials and collect information according to the questions. It can fully mobilize students' subjective initiative to carry out vivid interactive teaching, and cultivate students' independent thinking ability, information retrieval ability and comprehensive application ability of multidisciplinary knowledge, which is ultimately transformed into the improvement of innovative practice ability [17]. Meanwhile, in the process of independently exploring the optimal scheme, students develop the thinking inertia of solving medical engineering problems and form their medical engineering thinking. Also, TBL teaching mode is integrated into the four-track internship teaching method. In this method, students are divided into groups to complete the task, brainstorm the best plan within the groups, clarify the responsibilities of each member, and cooperate with each other. The teachers and students constantly adjust the experimental ideas and methods during the task execution, and finally complete the project design with high quality. In this process, students have a deeper understanding of the design of experimental scheme, the implementation and adjustment of experimental methods. Meanwhile, their innovative practice ability and medical engineering thinking mode are further exercised, and their teamwork ability is also improved [18]. Therefore, in the data statistical analysis results of this study, in terms of innovative practice ability and medical engineering thinking, students in groups B and C were better than group A, and group C with the four-track teaching method performed best; in terms of cooperation ability, the scores of group C were significantly better than that of groups A and B.

4.3. The LBL-CBL-PBL-TBL four-track internship teaching method helps to improve students' mastery of practical skills, and students have high satisfaction with this teaching mode.

In the four-track internship teaching method, students have high learning enthusiasm, their innovative practice ability and teamwork ability have been trained, and their medical engineering thinking has been cultivated. Finally, students' mastery of internship skills has been significantly improved, and students have a high degree of recognition and satisfaction for this internship teaching model. Therefore, in the statistical analysis of the student questionnaire, the satisfaction of teaching model and the mastery of practical skills of group C were better than those of groups A and B.

5. Conclusions

As a multidisciplinary interdisciplinary specialty, biomedical engineering requires students to have high comprehensive quality and ability. In the internship teaching of biomedical engineering, adopting LBL-CBL-PBL-TBL four-track teaching method can effectively improve students' learning enthusiasm, improve students' comprehensive ability level in all aspects, and improve their mastery of practice skills, which has high application and promotion value in the internship

teaching process of this major.

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