Reforming teaching methods by integrating dental theory with clinical practice for dental students

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Abstract

Background. Transitioning from theoretical medicine to clinical practice is both an important and difficult process in the education of dental students. Thus, there is an urgent need for teaching methods that can improve the ability of dental students to integrate dental theory with clinical practice.

Methods. First, we conducted problem-based learning training, based on real clinical cases, for dental students. The students were then assigned to dentist/patient roles to rehearse and perform simulated clinical scenarios. Finally, questionnaires, clinical patient care scores, and performance assessments were utilized to evaluate and compare the effectiveness of this training with that of traditional teaching methods.

Results. The abilities of the students after using this reformed teaching method markedly increased in terms of the treatment of and communication with patients. Among the 30 enrolled students, 29 liked the method, found it time-efficient, and believed that it could help enhance their problem-solving confidence and interest in prosthodontics. They also believed that this teaching method could help them gain a good understanding of related theoretical material, generally thought that the reformed teaching method was more valuable than the traditional approach, and would like to introduce it to others.

Conclusion. After the teaching method change, the students not only achieved better scholastically, but also demonstrated greater accuracy in diagnosing the conditions of patients and formulating treatment plans. It was much easier for them to obtain recognition from patients, indicating that this method is effective for dental students.

Introduction
Transitioning from a medical theoretical education to clinical practice is an important, but difficult, process for dental students. Clinical practice is usually conducted in the last year of study, and some do not ever participate in clinical practice (*D Xu et al, 2010*). During traditional clinical practice, students cannot actually perform operations on patients, and do not have enough time to communicate with patients in the clinic. They can only observe how teachers operate and communicate with patients, or only partly participate in treatments. This inadequate clinical experience

37 highlights the challenge of merging theoretical knowledge and clinical practice in dental education. Dental students

38 do not know how to respond when faced directly with patients. They cannot apply their theoretical knowledge to

39 clinical diagnosis and treatment, which could easily lead to medical disputes, especially when the doctor–patient

40 relationship is already strained. Therefore, there is an urgent need for an effective teaching method that can integrate

41 dental theory with clinical practice when educating dental undergraduate students.

42 Problem-based learning (PBL) training is designed to use a high-authenticity task, emphasizing the study of learning

43 in complex and meaningful problem scenarios. Learners can solve problems through self-exploration and cooperation,

44 and can learn scientific knowledge based on the problem. Students develop both the skills to solve the problem and

45 self-learning abilities. PBL training has been applied in medical education for more than 40 years (*Edward &*

46 *Thompson, 2013*). Previous studies have shown that medical students who underwent PBL training had better results

47 in medical licensing examinations and clinical practice, and showed a better understanding of clinical problems and a

48 capacity for self-learning than students who underwent traditional teaching (*Blake, Hosokawa & Riley, 2000; Hoffman*

49 *et al., 2006; Okubo et al., 2012; Khan et al., 2007*). Although PBL training has been widely used, Kinkade et al.'s

50 research showed that its application in American medical colleges has declined (*Kinkade et al., 2005*), mainly because

51 teachers realized that PBL training preparation was time consuming and required the use of more staff. For that reason,

52 the practicality of spending more human resources to conduct PBL training has been questioned (*Distlehorst et al.,*

53 *2005; Colliver, 2000; Farnsworth, 1994; Kirschner, Sweller & Clark, 2006*). China, with its rising educational reform,

54 has been gradually introducing PBL training in medical education. Some researchers have investigated the use of PBL

55 training in Chinese medical colleges, and found that PBL training had been applied in 43 medical colleges, and its

56 utilization rate in the pre-clinical curriculum was about 50% (*Fan, Kosik & Tsai, 2014*). However, there have been

57 very few reports showing the effectiveness of PBL training in dental undergraduate education.

58 Above all, a reform of dental education that can better combine theoretical knowledge with clinical practice is needed

59 (*Du et al,2010*). Traditional dental education has always used lecturing as the main teaching method, with an emphasis

60 on acquiring basic theoretical knowledge. Although this teaching method can help students grasp knowledge points

61 and holistic theory, it cannot track their initiative. Therefore, students lack the ability to practically apply their

62 knowledge, the capacity for self-learning, and clinical reasoning experience (*Wang, J. et al, 2010*). It is very difficult

63 for students to link clinical practice with theoretical knowledge, or to apply material from a lecture to solve clinical

64 problems when faced with real patients. Although many educational models have been proposed for dental students,

65 the critical transition from theoretical teaching to clinical practice training remains unacknowledged (*Prince, 2000*).

66 Since specialized teachers in medical colleges often concurrently work as consultants in clinics, their dedicated

67 teaching time is very limited. It is impractical to abolish the existing teaching method completely and replace it entirely

68 with the PBL teaching method. It is more appropriate to find a compromise between these two teaching methods, one

69 that is both practical and better at fulfilling the professional training requirements for dental students (*S Baozhi et al,*

70 *2003*). Furthermore, from the feedback of students, we found that those who had been taught using traditional methods

71 lacked not only sufficient capability in clinical practice, but also a satisfactory ability in communicating with patients.

72 These students overlooked some necessary details, such as their appearance, attitude, tone and rate of speech, way of

73 expression, etc., when communicating with patients (*Du et al, 2013*), and they did not show enough consideration to

74 their patients before and during treatments. All these factors may cause medical disputes and patient mistrust of

75 dentists, and they may also have negative effects on the formulation of an accurate diagnosis and treatment plan.

76 Given the factors above, we designed a clinical simulation PBL training method to both improve the ability of dental

77 undergraduate students to integrate dental theory with clinical practice, as well as enhance their professional skills,

78 and we compared this method's efficacy with that of the traditional teaching method.

79 **Materials & Methods**

80 **Ethics Statement**

81 A standard written informed consent procedure was included in the protocol, and was reviewed and approved by the

82 Ethics Committee of China Medical University. All the participants were over the age of 18 years, and gave their

83 written consent after the nature of the study had been fully explained. The research was approved by the Ethics

84 Committee of China Medical University, and conducted in full accordance with the World Medical Association

85 Declaration of Helsinki.

86 **Teaching objects and grouping**

87 PBL training was first conducted based on real clinical cases. To investigate whether the clinical-simulation PBL

88 training method was applicable to dental undergraduate teaching, we divided 60 students into two groups, 30 of whom

89 underwent PBL training while the other 30, as the control group, received traditional teaching. Questionnaires, clinical

90 patient care scores, and performance assessments were utilized to evaluate the effectiveness of PBL training when

91 compared with that of traditional teaching.

92 Thirty fifth-grade undergraduates from the School of Stomatology, China Medical University, participated in PBL

93 training in 2017: 11 males and 19 females. Another 30 undergraduate students from the same grade who underwent

94 normal class teaching without PBL training were set as the control group: 11 males and 19 females. The 30 students

95 in each group were further divided into five subgroups, with six in each subgroup. Each subgroup was comprised of

96 members with different cognitive characteristics, aptitudes, and personalities. There were distinct differences among

97 group members, but the overall study ability level of each subgroup was consistent.

98 **Selection of four clinical cases for PBL training**

99 The four selected clinical cases covered the basic elements of prosthodontics, including dental defect repair, fixed

100 partial denture repair, removable partial denture repair, and complete denture repair. Prostheses were applied as the

101 main treatments for all cases. However, before the final installation of the prostheses, pre-treatments such as dental

102 treatment of oral medicine, periodontal treatment, oral extraction surgery, etc., had been performed.

103 **Design of the training protocol**

104 The students were given enough time for systematic discussion and analysis of differential diagnoses, pre-treatment

105 plans, and restoration treatment plans of the four cases in their allocated groups. They were then asked to devise a

106 reasonable and comprehensive treatment plan. The students undergoing PBL training conducted a simulated clinical

107 diagnosis and treatment, taking turns to play the roles of doctor and patient, while the remaining students in the same

108 group pointed out errors and proposed suggestions. All students repeated the practice until they received satisfactory

109 evaluations from teachers and student judges.

110 Teachers provided the PBL problems related to the four clinical cases one week in advance, and then announced the

111 four cases to the students. Each group of students worked as a team to search the relevant literature, and then submitted

112   a summary report. Each team member was allocated an approximately equal amount of work according to their own

113   characteristics after an internal group discussion. When any team had questions, the teacher would provide necessary

114   guidance.

115   After each student had worked independently, all team members were asked to exchange information to discuss the

116   problem-solving process, and then to draw conclusions. Teachers encouraged discussions, ensuring that each group

117   stuck closely to the PBL theme, and re-examined any previous errors. The group members continued to revise their

118   written reports with any new relevant literature on the problems posed by the teachers.

119   The teachers instructed the students to summarize their experiences and deficiencies throughout the training process.

120   They also evaluated the students' independent learning and collaborative abilities.

121   After listening to the presentations of all the groups, the teachers gave comments on the answers to the PBL questions,

122   and then provided any necessary corrective suggestions. Professional treatment advice was also given to each group

123   based on their treatment plan.

124   **Evaluations**

125   Questionnaires, clinical patient care scores, and performance assessments were utilized to evaluate the effectiveness

126   of the PBL training when compared with that of the traditional teaching approach. After the training, a survey of the

127   students was taken, including their responses to changes in their general abilities or skills, changes in their treatment

128   or communication abilities, the cognition of the teaching method, etc.

129   Second, teachers selected five real patients in the clinic, and two groups (the training group and control group) of

130   students independently admitted them. The patients selected needed dental defect repair, fixed partial denture repair,

131   removable partial denture repair, and complete denture repair. The teachers filled out the clinical case score sheet

132   (total 100 points, table 1), which included evaluations on the students' abilities in communicating with patients, their

133   auxiliary examinations before operation and differential diagnosis, the design and description of their treatment plans,

134   etc. The teachers scored each student's performances for all items on the sheet, and we compared the scores of the

135   PBL training group with those of the control group.

136   Finally, a paper examination on prosthodontics was used to investigate the learning outcomes of the two groups of

137   students. The types of examination questions were multiple choice, fill in the blank, short answers, and case analysis

138   questions. Full marks for the examination was 100 points, with 60 points or less considered a failure, between 60 and

139   90 points considered a pass, and 90 or more points considered excellent.

140   The test scores of the groups were expressed as mean value ± standard deviation. Statistical calculations were done

141   with SPSS (Chicago, IL, USA) 21.0 Windows software. T-test was used to analyze differences of the data between

142   the groups. A $p < 0.05$ was regarded as significant difference.

143   **Results**

144   After the end of the clinical simulation PBL training curriculum, students were surveyed to evaluate the effect of the

145   training. Figures 1 to 5 show various aspects of the questionnaires, such as student responses to questions about

146   changes in their general abilities or skills, changes in their special abilities of treating diseases or communicating with

147   patients, the cognition of the teaching method, etc. The results showed that the general abilities or skills of the students

148   after the PBL training had markedly increased (Figure 1), including their abilities to independently search literature,

149   their comprehensive and logical analysis skills, their teamwork ability, and their curiosity and exploratory desire of

150 professional knowledge. Moreover, their special abilities in treating diseases or communicating with patients,
151 including understanding indications for repair, correctly diagnosing diseases, developing treatment plans, quickly and
152 accurately recognizing the patient's condition, communicating with and understanding patients, had notably increased
153 (Figure 2). This teaching method was highly regarded by the students (Figure 3). Among the 30 students, 29 liked this
154 teaching method. Twenty-eight students considered this method an efficient use of time. Twenty-six believed that this
155 teaching method could help enhance their problem-solving confidence. Twenty-seven students believed that this
156 teaching method could increase their interest in prosthodontics, while 25 believed that this teaching method could help
157 them gain a better theoretical knowledge of prosthodontics. Twenty-eight students were keen to introduce this teaching
158 method to others. Twenty-nine students believed that the value of this teaching method was greater than that of the
159 traditional teaching approach (Figure 4).
160 The score sheets for clinical practice (Table 1) were designed to evaluate the students' clinical performance, including
161 meeting the requirements for appearance; their attitude to the patients, their ability to communicate with patients,
162 diagnose diseases, make a differential diagnosis, perform auxiliary examinations and operational examinations; devise
163 early restoration treatment plans before making the prosthesis; patients' satisfaction; and so on. Table 2 shows that
164 students who underwent clinical-simulation PBL training received a score of 88.90 ± 2.29, which was significantly
165 higher than the score of 67.13 ± 2.20 received by the students who had not undergone the training ($p<0.05$). This
166 suggests that the clinical-simulation PBL training method was very helpful for students in the clinical management of
167 patients. More specifically, the sub-scores of items 3 and 10 were respectively 14.17 ± 0.38 and 9.53 ± 0.63, showing
168 significant improvement as compared with those (9.27 ± 1.46 and 6.80 ± 0.41) of the students in the control group
169 ($p<0.05$).
170 Figure 5 shows the prosthodontics examination scores of the clinical-simulation PBL training group and the control
171 group. The average score of the training group was 82.80 points, and the pass rate and the excellent rate were
172 respectively 90% and 40%. The average score of the control group was 74.33 points, and the pass rate and the excellent
173 rate were respectively 70% and 23.33%.
174 **Discussion**
175 Learning clinical reasoning is complex, as it includes the application of professional knowledge and the accumulation
176 of experience from actual clinical cases. Due to limited time for clinical practice, dental students have limited contact
177 with patients, both in type and quantity, and, for the patients' safety, clinical teachers do not allow undergraduate
178 students to treat patients independently. Traditional teaching methods only focus on theoretical knowledge and lack
179 clinical reasoning training, without a link between theoretical knowledge and clinical cases. After students graduate,
180 their theoretical knowledge cannot be adequately applied in clinical practice, and they do not have enough self-
181 confidence nor communication abilities when faced with patients. Therefore, PBL training can be the key for medical
182 students (*Eva, 2005; Ark, Brooks & Eva, 2006; Rencic, 2011; Miflin, Campbell & Price, 2000; Wood, 2003*). PBL
183 emphasizes that studies should be designed based on real life scenarios with complex situations and meaningful
184 problems. Problems are solved through the cooperation of the students, and they can learn the implicit scientific
185 knowledge behind questions and form problem-solving skills and independent learning abilities (*Srinivas & Susarla,*
186 *2004; Thammasitboon, 2007*). This method is considered to stimulate self-directed learning, and to improve the

187 capacity of lifelong learning and the level of multidisciplinary integration (*Distlehorst, 2005*). The PBL training

188 method mainly involves discussions in small groups, focusing on the patients' medical history, physical examination,

189 and laboratory data, as well as ultimate diagnosis and treatment plans.

190 With rapid developments in dental medical technology, dentists must have the ability to independently learn new

191 information and skills. Dentists should also have a good ability to communicate, in order to avoid misunderstandings

192 with their patients. A single traditional teaching approach for dental education is no longer applicable for dental

193 students. It is necessary to improve the existing teaching methods and add innovative methods.

194 In this study, we proposed simulated clinical PBL training on the basis of traditional teaching methods. First, several

195 typical clinical cases were chosen and compiled into templates. Students collected the necessary information through

196 literature review and then discussed within small groups to solve clinical problems, formulate rational treatment plans,

197 and determine the most suitable treatment for patients. During this PBL training, students were instructed how to apply

198 their basic dental theoretical knowledge to clinical cases. The training provided students with an opportunity to

199 maximize simulated clinical practice, stimulating their self-learning capacities and problem-solving skills when faced

200 with real patients in the clinic.

201 In addition to being able to apply basic dental theoretical knowledge to clinical cases, a dentist should also have a

202 satisfactory ability in communicating with patients, enabling them to obtain more relevant information about medical

203 history and current diseases, and to formulate accurate diagnosis and treatment plans. Therefore, in the second part of

204 the training, some of the students in the PBL group took turns playing the roles of doctor and patient, conducting

205 simulated clinical diagnosis and treatment, while the other students in the same group acted as judges to point out

206 errors. All students repeated the practice until they received satisfactory evaluations from the teachers and their peers.

207 The results showed that students generally believed that PBL teaching could promote critical thinking ability more

208 than traditional teaching methods, and that this teaching method was very helpful for improving their capacity for self-

209 learning. After the training, students showed improved ability to communicate with patients, greater accuracy in

210 diagnosing patients' conditions and formulating treatment plans, and it was much easier for them to obtain the

211 appreciation of patients. Furthermore, they believed that PBL training could facilitate the comprehensive utilization

212 of various theoretical facts into oral professional and clinical practice, and that the clinical scenario simulation during

213 the PBL training was especially helpful for the improvement of their linguistic skills, logical thinking, and clinical

214 practice ability. Additionally, the results of the prosthodontics examination scores suggested that PBL training

215 deepened students' understanding of the related theoretical knowledge, leading to improved performances. This

216 teaching method was highly regarded by the students, and the results indicate that clinical-simulation PBL is likely to

217 be an effective teaching method for dental undergraduate students.

218 Through this study, we found many factors that might affect the effectiveness of clinical-simulation PBL training for

219 dental undergraduate students: (i) appropriate clinical case selection, (ii) reasonable proposed problems, (ii) abundant

220 rehearsal and role-play of dentists and patients, and (iv) sufficient preparation, discussion, and practice time. When

221 choosing cases, teachers should fully consider common occurrences in local clinics. For example, patients in

222 prosthodontics clinics often need the consultation of doctors from other oral departments, such as oral medicine, oral

223 periodontal, oral surgery, etc. Therefore, the overall oral health should be considered overall. Second, implementing

224 the core part of PBL training can be difficult. The proposed PBL problems directly influence the effectiveness of
225 student learning, and should be designed to attract the student's interests in understanding the cases. When discussions
226 are restricted to certain issues, teachers should remind students to extend their range of thought, and should ultimately
227 help students find satisfactory answers and develop rational prosthetic treatment plans (*Barrows & Tamblyn, 2003;*
228 *Hung, 2011; Li et al., 2015*). Third, abundant rehearsal and role-play of dentist and patient significantly enhance the
229 effectiveness of the clinical-simulation PBL training for dental undergraduate students. Cultivation of the students'
230 communication and understanding has always been emphasized in modern higher education. For dental students,
231 abundant rehearsal and role-play may help them comprehensively understand patients, which is crucial for achieving
232 satisfactory diagnosis and making treatment plans. Fourth, during training, sufficient time should be given to teachers
233 to ensure they have enough time to instruct students properly, and to students so that they have ample time to access
234 relevant information, have full discussions, and enough repeated practice to obtain good results.
235 Although satisfactory results have been obtained in this study, we noticed that there were still some challenges in
236 conducting clinical-simulation PBL training in dental schools. There was only limited funding for dental education
237 and educational research. Most of the teachers who are normally dentists did not have enough specific time allocated
238 for clinical-simulation PBL training. Many students lacked adaptability to this training method. However, we believe
239 that with its increasing recognition and optimization by dentists and students, clinical-simulation PBL training may
240 become more widely applied in dental education.

241 **Conclusion**
242 In this study, clinical-simulation PBL training was designed to integrate dental theory with clinical practice for dental
243 students. PBL training was first conducted based on real clinical cases. Students had the opportunity to repeatedly
244 participate in role-play as dentists and patients to simulate clinical scenarios. The results showed that students
245 generally believed that PBL teaching could promote their critical thinking ability more than traditional teaching
246 methods, and that this teaching method was very helpful in improving the capacity for self-learning. After the training,
247 the students showed improved ability to communicate with patients, greater accuracy in diagnosing patient conditions
248 and formulating treatment plans, and it was much easier for them to obtain the acknowledgement of the patients.
249 Furthermore, PBL training was considered to facilitate the comprehensive utilization of various theoretical facts into
250 oral professional and clinical practice, and clinical scenario simulation during the PBL training was especially helpful
251 for the improvement of linguistic skills, logical thinking, and clinical practice ability. The results of the prosthodontics
252 examination scores suggested that PBL training can also deepen students' understanding of related theoretical
253 knowledge, leading to improved performances. Overall, this teaching method was highly regarded by the students.
254 These results indicated that clinical-simulation PBL is likely to be an effective teaching method for dental
255 undergraduate students.
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Figure 1

Student responses to the questions about the change in their general abilities or skills after the clinical-simulation PBL training

The figure shows that student responses to the questions about the change in their general abilities or skills after the clinical-simulation PBL training

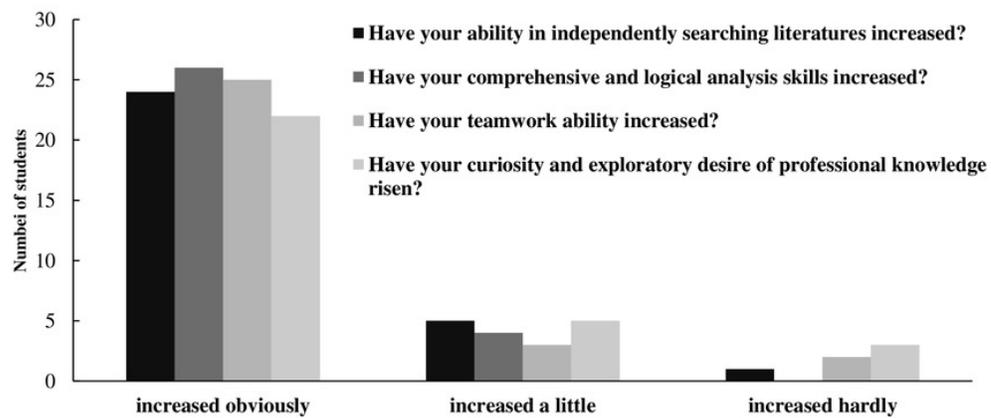



Figure 2

Student responses to the questions about the change in their special abilities in treating dental diseases or communicating with patients after the clinical-simulation PBL training

The figure shows that student responses to the questions about the change in their special abilities in treating dental diseases or communicating with patients after the clinical-simulation PBL training

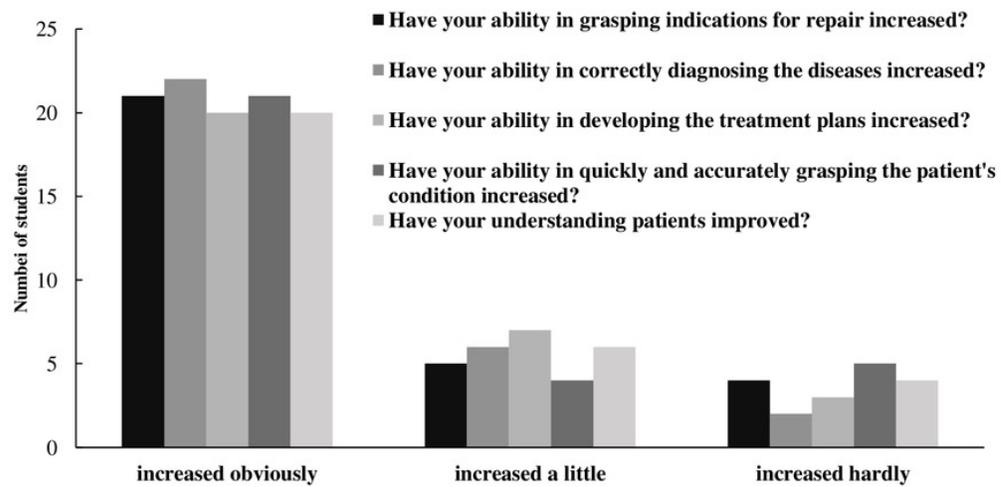



Figure 3

Student responses to the questions about their cognition of the teaching method

The figure3 shows that student responses to the questions about their cognition of the teaching method

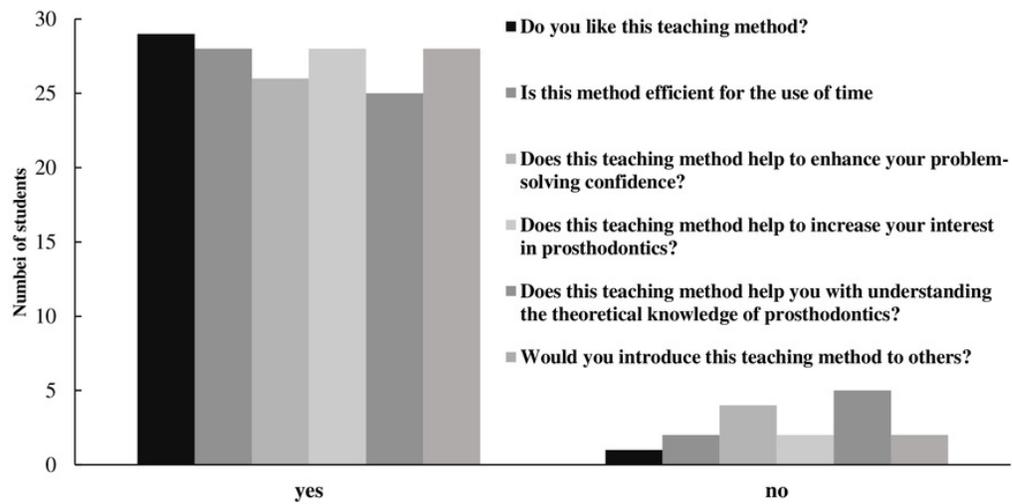



Figure 4

Student responses to the question: How did you find the value of this teaching method, as compared with that of the traditional teaching?

The figure4 shows that student responses to the question: How did you find the value of this teaching method, as compared with that of the traditional teaching?

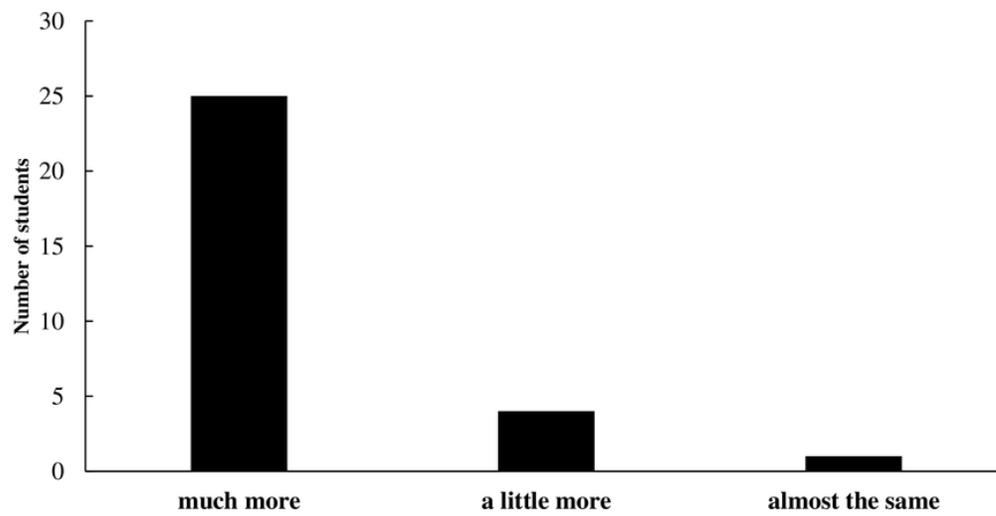
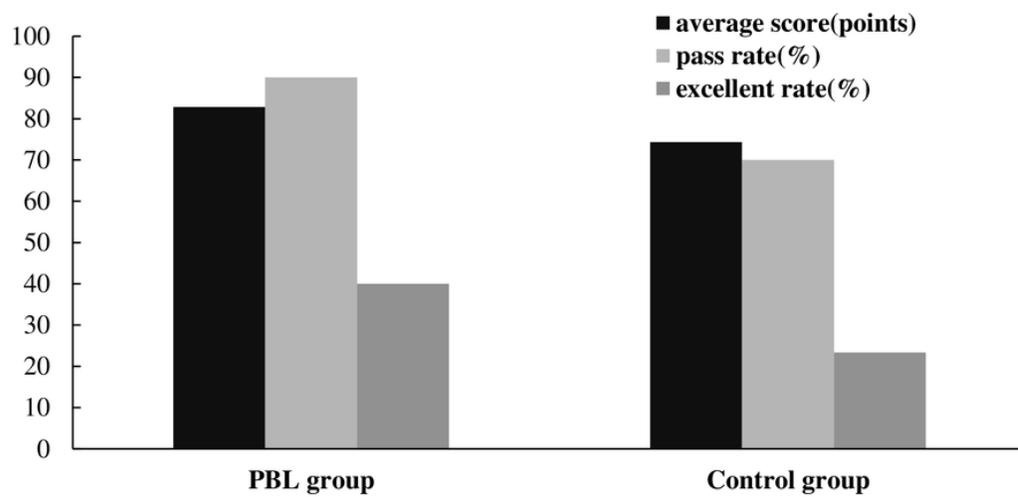



Figure 5

Paper examination results of the clinical-simulation PBL training group and the control group

The figure shows that paper examination results of the clinical-simulation PBL training group and the control group

Score sheet for clinical practice

The table shows that score sheet for clinical practice

Score sheet for clinical practice

Items and scoring rules	Scores (Max points)
1. Whether the appearance of the students meets the hygiene requirements. For example, whether the hat, mask, and glove are worn correctly.	5
2. Whether the students' attitude is pleasant when they face patients, and whether the speed of their speech is appropriate.	5
3. Whether the inquiry is detailed, whether the purpose and requirements of patients are understood, and whether the patients' urgent issues to be addressed and comprehensive history, including the history, drug allergies, etc., are collected.	15
4. When conducting oral preliminary examination, whether compliance with aseptic conditions is satisfactory, whether the mouth pulling action is gentle, and whether the chair position is appropriate.	5
5. Whether the oral examination is complete, comprehensive, includes a related repair inspection, includes the abutments, the gaps of missing teeth, the alveolar ridge and mucosa, occlusion, etc., and examination of other dental, periodontal, and mucosal conditions	15
6. Whether the auxiliary check is reasonable and comprehensive, whether the diagnosis of oral diseases is accurate and complete, and whether a reasonable differential diagnosis is conducted.	10
7. Whether the preliminary diagnosis is correct, whether the explanation of the oral condition is sufficiently detailed, and whether several possible treatment plans are developed, including any necessary collaborative treatments involving other departments.	15
8. Whether a reasonable treatment plan has been determined and described in detail	15

to the patients, including the desired treatment time, costs, possible problems, etc.

9. Whether the case history record is comprehensive and standardized.   5

10. Whether the patients' recognition and satisfaction are received.   10

	Total	100

Score results of the clinical simulation in the PBL training group and control group

The table shows that score results of the clinical simulation in the PBL training group and control group

1   Score results of the clinical simulation in the PBL training group and control group

Items	Scores of the clinical simulation PBL training group (points)	Scores of the control group (points)
1	4.63±0.61*	3.45±0.53
2	4.33±0.61*	3.12±0.61
3	14.17±0.38*	9.27±1.46
4	4.47±0.63*	2.87±0.63
5	14.53±0.51*	11.12±1.27
6	9.00±0.95*	8.03±0.67
7	9.03±0.76*	7.00±0.31
8	14.73±0.45*	12.20±0.85
9	4.47±0.63*	3.41±0.50
10	9.53±0.63*	6.80±0.41
Total points	88.90±2.29*	67.13±2.20

2   P.S.: Two groups of comparison * $p < 0.05$