

# PTEBL Teaching Method Combined with Caesar (Trauma Patient Simulator) Versus Traditional Teaching Method in The Training of Outstanding Doctoral Candidates in STB Skills: A Randomized Controlled Trial

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## Research Article

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# Abstract

**Background:** The “Stop The Bleed” (STB) campaign has achieved remarkable results since it launched in 2016, but there is no report on the application of a STB course combined with a trauma patient simulator. This study proposes the “problem-, team-, and evidence-based learning” (PTEBL) teaching method combined with Caesar (trauma patient simulator) based on the STB course, and compares its effect with the traditional teaching method in outstanding doctoral candidates training of hemostasis skills.

**Method:** Seventy-eight outstanding doctoral candidates program students (five-years and eight-years) were selected as the research subjects and were randomly divided into a control group (traditional teaching method, n=34) and an experimental group (PTEBL teaching method combined with Caesar, n=44). Their confidence of hemostasis skills and willingness to rescue were investigated before and after the course in both groups.

**Result:** Students' self-confidence of STB skills and willingness to rescue in both groups were improved after the class. Compared with the control group, students in the experimental group were more confident in compressing with bandages and compressing with a tourniquet after a class (compressing with bandages: control group  $3.9 \pm 0.8$  vs. experimental group  $4.3 \pm 0.7$ ,  $P=0.014$ ; compressing with a tourniquet: control group  $3.9 \pm 0.4$  vs. experimental group  $4.5 \pm 0.8$ ,  $P=0.001$ ) More students in the experimental group than the control group thought that the use of Caesar for scenario simulation could improve learning (control group 55.9% vs. experimental group 81.8%,  $P=0.024$ ), and showed higher teacher-student interaction (control group 85.3% vs. experimental group 97.7%,  $P=0.042$ ) The overall effectiveness of the teaching was better in the experimental group than the control group (control group 85.3% vs. experimental group 97.7%,  $P=0.042$ ). There was a significant positive correlation between teacher-students interaction and overall effectiveness of teaching ( $R=1.000$ ; 95%CI, 1.000-1.000;  $P<0.001$ ).

**Conclusion:** The PTEBL teaching method combined with Caesar can effectively improve students' mastery of STB skills, and overcome the shortcomings of traditional teaching methods, which has a certain promotional value in the training of outstanding doctoral candidates in STB skills.

## Background

Unintentional injury is the leading cause of death among people aged 1-45 years old, resulting in more than 160,000 deaths each year in the United States, and showing a gradually increasing trend<sup>[1]</sup>. Studies show that nearly 60% of the potentially survivable deaths were caused by hemorrhaging, which means controlling bleeding in a timely and effective manner is the key to preventing death in injury patients<sup>[2, 3]</sup>. The US military is the first to make a breakthrough in the study of traumatic hemostasis and has reduced battlefield mortality by 44.2% in the 16 years of war in Iraq and Afghanistan due to its medical advancements in the field of prehospital hemorrhage control<sup>[4]</sup>. A National Academies of Sciences, Engineering, and Medicine Report recommended that civilians deserved the care improvement benefits achieved through military medicine<sup>[5]</sup>. Thus, the White House launched a national public awareness

campaign, "Stop The Bleed" (STB), in October 2015 to educate and empower the public in bleeding control<sup>[6-9]</sup>. This campaign has been proved to achieve remarkable results<sup>[10]</sup>. Since its inception, the movement has gained more than 15,000 instructors in the United States and trained more than 120,000 people across the country<sup>[11]</sup>.

In China, injury is the leading cause of death and disability among the younger population, and the incidence of road traffic-related deaths is significantly higher than the average level of high-income and middle-income countries<sup>[12]</sup>. However, there is no report on the application of STB courses in China, and only some schools use Caesar to improve students' ability to deal with emergency and critical diseases<sup>[13]</sup>. At present, most traditional hemostatic trauma training in China is one-way skill training, which is carried out by three steps of "demonstration-exercise-examination". The traditional teaching method contributes to the improvement of operation proficiency. Still, it cannot effectively improve students' abilities of initial diagnosis, decision-making, and correct handling of bleeding due to the complexity of clinical scenes. Therefore, it's essential to introduce STB skills and proper teaching methods which are suitable for medical education in China.

Our team put forward a new teaching method named "problem-, team- and evidence-based learning" (PTEBL) in 2012<sup>[14]</sup>. This teaching method emphasizes problem-orientation team work, and evidence-based decisions to maximize student engagement and encourage interactive learning<sup>[15, 16]</sup>. Furthermore, in 2018, the Ministry of Education of China put forward "The Opinions on Strengthening the Collaboration between Medicine and Education to Implement the Outstanding Doctoral Candidates Training Program 2.0", which emphasized the teaching reform of practical skills in the training of outstanding doctoral candidates who were selected from normal medical training programs<sup>[17]</sup>. Therefore, based on the advantages of the STB course, combined with the teaching experience of our school, we adopted the PTEBL teaching method combined with using Caesar for the training of outstanding doctoral candidates, and proving the feasibility of this model, which can effectively overcome the shortcomings of the traditional teaching model.

## Methods

### Study design

This study is a randomized controlled trial, and the ethics committee of the hospital approved the research (ID: 2021-S078). All participants were randomly divided into the experimental group and the control group (Figure 1). The experimental group was taught with the PTEBL teaching method combined with the use of Caesar, and the control group was taught with the traditional teaching method. Based on the Likert scale and referring to prior studies<sup>[18]</sup>, a questionnaire (see Additional file 1 and Additional file 2) was conducted before and after class. Students were inquired about their willingness to rescue at the first scene of traumatic bleeding and their confidence in the three hemostatic skills. The theoretical and

operational scores of the experimental group were tested. The above results were used as the criteria for evaluating the effectiveness of teaching the PTEBL teaching method combined with the use of Caesar.

## Study participants and set up

The Grade 2018 students, who had just completed the basic course from XiangYa School of Medicine of Central South University were randomly divided into The Second XiangYa Hospital and The Third XiangYa Hospital in 2021. Among them, there were 34 students in The Second XiangYa Hospital (20 with five years of outstanding doctoral candidates training program, 14 with eight-years in clinical medicine), and 44 students in The Third XiangYa Hospital (19 with five years of outstanding doctoral candidates training program, 25 with eight-years in clinical medicine). All the subjects had informed consent to the contents of this study. Its grouping and implementation were as follows:

The experimental group (PTEBL teaching method + students practice with Caesar): 44 students of excellence training plan in The Third XiangYa Hospital. For experimental group students, we first introduced the background of trauma hemostasis, the core of the PTEBL teaching method, and the application of Caesar, the trauma patient simulator, which was recognized and operated by the students.

The control group (Traditional teacher lecturing + students practice with each other): 34 students of excellent training plan in The Second XiangYa Hospital. The conventional model was used for the students of control group, and the experimental intervention of teaching reform was not carried out. A questionnaire was given to the students to evaluate the effect of traditional teaching.

## Study protocol

For the control group, the traditional teaching model was adopted. Teachers explained and demonstrated three STB hemostasis techniques (compress with fingers, bandages, or a tourniquet). Then the students practiced these skills with each other.

For the experimental group, the PTEBL teaching method combined with the use of Caesar was adopted. The implementation plan of this method was as follows:

1) P-problem: In this part, teachers distributed courseware of trauma hemostasis and relevant authoritative guidelines to students before class. At the beginning of the class, the students were shown a scenario of traumatic bleeding in The Good Doctor, and the following questions were put forward: (Q1) How do you stop the bleeding effectively? (Q2) Can we do cardiopulmonary resuscitation directly? (Q3) Which actions were handled well in the video and which were not done well? Students were asked to study under the guidance of the above questions. After the lecture, the teacher distributed classroom tests (see Additional file 3) to students to test their mastery of the theoretical knowledge of trauma hemostasis.

2) T-team: In this part, students were randomly divided into several teams of 2-3 members, who respectively roleplay the following roles: two doctors (roles A and B) and one family member (role D,

which is not available when the team has only two students). After the teacher plays a video introducing Caesar and students have practiced hands-on bleeding control skills, a scenario simulation is then carried out based on the wounds on Caesar : You and your companions (roles A and B) witnessed a severe car accident. The injured person (role C, Caesar) was conscious, but his popliteal arteries kept spurting blood. What would you do to rescue Caesar? Caesar can provide feedback to inform students of changes in vital signs and evaluation of the hemostatic effect accurately. Two scenarios were simulated for each group, and each operation was timed. Fluency and completion of hemostasis operation were scored to test students' mastery of STB operation skills.

3) E-evidence: In this part, students were asked to diverge their thinking through materials distributed by teachers, consult the latest literature, and jointly discuss the latest techniques or concepts of "trauma hemostasis" in class.

A questionnaire was conducted before and after the course (see Additional file 1 and Additional file 2) to evaluate the effect of traditional teaching in both the control group and experimental group. The competencies needed for medical students in terms of specific standards were established on the basis of the latest International Medical Association guidelines and other relative studies<sup>[18-24]</sup>.

## Statistical analysis

Statistical analysis and mapping were performed with SPSS 26.0 (IBM Corp., Armonk, NY, USA) and Prism 9.0 (GraphPad Software, San Diego, CA, USA). A t-test was used to analyze the measurement data (mean ± Standard Deviation), a chi-square test was used to analyze the nominal data, and a rank-sum test was used to analyze the ordinal data. P < 0.05 was regarded as statistically significant. Spearman's correlation coefficient between the independent variables and the results were presented as a correlation heatmap.

## Results

### Demographics

A total of 78 participants completed the study, including 34 in the control group and 44 in the experimental group. In this study, 78 pre-course and after-course questionnaires were distributed to the subjects, with a recovery rate of 100%. Through analysis of the pre-course questionnaire, we found that there was no statistical difference in sex, age, hemostatic experience, hemostatic confidence and willingness of rescue between the two groups ( $P > 0.05$ ) (Table 1). Among all the subjects, there were 40 males and 38 females, with an average age of  $20.3 \pm 0.6$  years.

### Willingness to rescue at the first scene of trauma bleeding

There was a significant increase in the number of subjects who chose rescue at the first scene of traumatic bleeding after training ( $P < 0.001$ ). However, there was no statistical difference between the two groups ( $P = 0.660$ ) (Table 2). Before and after the training, there was no statistical difference in the

willingness to rescue between the five-years outstanding doctoral candidates training program students and the eight-years medical students in the experimental group and the control group ( $P = 0.180$  and  $0.112$ , respectively).

## **Confidence in various hemostatic skills**

The students' self-confidence of compressing with fingers, bandages, or a tourniquet after class in both groups was statistically higher than that before class ( $P < 0.001$ ). In compressing with bandages and compressing with a tourniquet, the average self-confidence of students in the control group was  $3.9 \pm 0.8$  and  $3.9 \pm 0.4$  respectively, while that in the experimental group was  $4.3 \pm 0.7$  and  $4.5 \pm 0.8$  respectively, which was significantly higher than that in the control group ( $P = 0.014$ , and  $0.001$ , respectively). This data was presented in Table 3. Before and after the training, there was no statistical difference in the students' confidence of the three hemostatic methods between the five years of outstanding doctoral candidates training program students and the eight-years clinical medicine students in the experimental group and the control group ( $P = 0.193$ ,  $0.603$ , and  $0.907$ , respectively).

## **Scores and scenario simulation results of experimental group**

All 44 students who participated in the class theory test of this course passed the test (scores over 60 are passed) with a pass rate of 100%, and the average score was  $97.1 \pm 5.28$ . In the final stage of the hemostasis operation with Caesar, all groups achieved the task of treatment, which made the vital signs of the trauma patient tend to be stable. The scores and time-consumption of the two scenario simulations in each group are shown in Table 4. The score of the second scenario simulation was significantly improved compared with the first one ( $P < 0.001$ ). Similarly, the time-consumption in the second scenario simulation was significantly less than that in the first one ( $P = 0.001$ ). There was no significant difference between the five years of outstanding doctoral candidates training program students and the eight-years clinical medicine students in scores and time-consumption of scenario simulation ( $P > 0.05$ ).

## **Students' approvement of various abilities improvement**

After attending the course, 81.8% (36/44) students approved that the scenario simulation improved the learning of traumatic hemostasis in the experimental group, while in the control group, only 55.9% (19/34) students approved that the operation improved the learning of traumatic hemostasis, and the difference was statistically significant ( $P=0.024$ ). In terms of teamwork skills, clinical thinking and problem analysis, more than 80% of the students in both groups approved that their abilities had improved, and there was no statistical difference between the two groups ( $P=0.228$ ,  $0.140$ , and  $0.242$ , respectively). The degrees of students' approvement on various abilities improvement are shown in Figure 2.

## **Evaluation of the effectiveness of teaching**

All participants were satisfied or very satisfied with the teachers' enthusiasm, the interaction between teachers and students, and the overall effectiveness of the teaching. 93.2% (41/44) and 85.3% (29/34) of the students in the experimental group and the control group respectively were very satisfied with the teacher's enthusiasm for teaching, and there was no statistical difference between the two groups ( $P=0.258$ ). 97.7% (43/44) and 85.3% (29/34) of the students in the experimental group and the control group respectively were very satisfied with the interaction between teachers and students, and the difference was statistically significant ( $P = 0.042$ ). After the course training, 97.7% (43/44) of the students in the experimental group were very satisfied with the overall effectiveness of the teaching, while only 85.3% (29/34) of the students in the control group were very satisfied with the overall effectiveness of the teaching, which was statistically lower than that in the experimental group ( $P=0.042$ ). The proportions of students who were very satisfied with various variables are shown in Figure 3.

## Correlation heatmap of relevant independent variables

Spearman correlation analysis was used to analyze the correlation of independent variables. Through the analysis, it was found that there was a significant correlation between the students' confidence of the three hemostatic methods pre-course, between the students' confidence of the three hemostatic methods post-course, between the improvement of four abilities improvement, and between the satisfaction with the three variables of effectiveness of the teaching( $|r|>0.6$ ,  $P<0.05$ ). Among them, 7 groups of variables were highly correlated( $|r|>0.8$ ,  $P<0.05$ ). The highest positive correlation was between overall effectiveness of the teaching and interaction between teachers and students ( $R=1.000$ ; 95%CI, 1.000-1.000;  $P<0.001$ ). Then the second highest positive correlation was between problem analysis improved and teamwork skills improved ( $R=0.886$ ; 95%CI, 0.753-0.956;  $P<0.001$ ). The results are shown in Figure 4.

## Discussion

Injury is the leading cause of death among young adults. The key element in the death of injury patients is failure to control bleeding in a timely and effective manner. For this reason, many projects such as the STB campaign, the Hartford Consensus, and the Federal Emergency Management Agency's "You are the Help until Help arrives" are calling for the strengthening of trauma hemostasis education for the general public<sup>[6, 8, 9, 25]</sup>. The STB campaign has been implemented for six years and has achieved remarkable results. The research of AlSabah et al. shows that nearly 90% of participants expressed that the STB campaign contributed to promoting health and improving personal safety awareness<sup>[26]</sup>. Schroll et al. [27] pointed out that the traumatic hemostasis course is important to the teaching of medical students. The research of Sarah Beth Dinwiddie et al.<sup>[28]</sup> also proved that STB training is effective at improving students' knowledge and confidence. However, the traditional teaching method, of one-way skill training, is still adopted in China at present. This is taught only through teachers' explanations and students' personal operations, and cannot be effectively integrated with clinical practice. For the education of outstanding doctoral candidates, more attention should be paid to students' ability of innovation, exploration, and cooperation. The research of Faisal et al.<sup>[29]</sup> shows that problem-based learning is more

helpful to the training of medical students than traditional lecture-based learning. Burgess et al.<sup>[30]</sup> introduced team-based learning on the basis of problem learning, and Chakraborti et al.<sup>[31]</sup> introduced evidence based learning on the basis of team learning, both of which have proven to achieve beneficial results in medical education. Based on the above reasons, we hope to introduce STB courses suitable for the training of outstanding doctoral candidates, to make up for the shortcomings of traditional teaching methods. However, the traditional STB course has also exposed its drawbacks in the implementation process. The research of Villegas et al.<sup>[32]</sup> shows that people reported overwhelmingly that the model is not authentic enough. If the training is more realistic, it will be more effective. The research of Zwislewski et al.<sup>[33]</sup> also emphasized the importance of hands-on training in STB skill learning. Therefore, we adopted PTEBL teaching method combined with Caesar, the trauma patient simulator, for the STB skills training of outstanding doctoral candidates.

In this study, all students in the experimental group passed the theoretical test and the scenario simulation test. They also significantly improved their confidence in the three basic skills in the STB course and their willingness to rescue at the first scene of traumatic bleeding. This shows that this teaching method can effectively teach STB skills and help students master and implement them. In the scenario simulation test, the second scenario simulation takes less time than the first scenario simulation, and the average performance was improved, which affirms the training effect of teamwork and scenario simulation on students' mastery and proficiency in STB skills. In our research, we found that although using traditional teaching methods could improve students' confidence in various hemostasis skills, students' confidence was still low after the class. This feature is more prominent in the compressing with bandages and compressing with a tourniquet technique, which may be related to the fact that traditional one-way skill training does not allow students to use these two more difficult operations flexibly. The experimental group's confidence in the compressing with bandages and compressing with a tourniquet technique after the class was significantly higher than that of the control group, which indicate that the PTEBL teaching method can effectively improve students' mastery of hemostasis skills and can also make up for the shortcomings of traditional teaching methods. This is closely related to the superiority of STB courses. The research of Ali et al. has proven that the STB course can promote the correct placement of tourniquet and increase levels of comfort in 75% of students<sup>[34]</sup>, which is consistent with the results of our research. In addition, in the after-school questionnaire, we found that compared with the traditional teaching method of students' autonomous operation, students responded that the use of Caesar for scenario simulation could improve the effectiveness of learning, which is consistent with the results of Villegas' research<sup>[32]</sup>. We believe that the use of Caesar, for more realistic scenario simulations, is also one of the reasons for the experimental group's higher confidence in the compressing with bandages and compressing with a tourniquet technique.

The heat map shows that the degree of interaction between teachers and students is highly correlated with the overall effectiveness of the teaching, indicating that students' mastery of skills largely depends on teacher-student interaction. The research of Burgess et al.<sup>[35]</sup> proved that team-based learning could improve students' participation in the course. The PTEBL teaching method uses teamwork as the core

and increases the communication between students and teachers. As shown in Figure 3, when the teachers' enthusiasm is the same, the PTEBL teaching method combined with Caesar can effectively improve the interaction between teachers and students, thereby further improving the overall effectiveness of the teaching.

In summary, the PTEBL teaching method combined with Caesar has achieved remarkable results. However, both the traditional method and the PTEBL method can improve students' confidence in hemostatic skills and the willingness to rescue. The PTEBL method improves some of the students' trauma hemostatic skills to a greater extent, and can create a better teaching atmosphere and achieve better effectiveness in teaching STB skills, which is consistent with our expected results.

However, the course still has some limitations. For example, the cost of Caesar, the trauma patient, is relatively high and difficult to obtain, which imposes certain restrictions on the implementation of teaching. Besides, many studies have shown that although the STB course can effectively improve students' trauma hemostatic skills, the retention of these skills was poor<sup>[7, 36, 37]</sup>. Therefore, how to increase the retention of skills is extremely important to improve the mastery rate of trauma hemostasis skills. In addition, the research of Dhillon et al.<sup>[38]</sup> showed that although STB courses can achieve decent results, the general public's acquisition rate of necessary equipment for these skills is low. Cost, time and accessibility of items during an event are still the most common obstacle. Therefore, in order to improve the general public's willingness to treat bleeding patients, we must not only strengthen trauma hemostasis education, but also make it so people can easily obtain the required materials for a traumatic bleeding situation. Therefore, the teaching reform of STB skills can be further explored.

## Conclusion

This study evaluates the effectiveness of using the PTEBL teaching method combined with Caesar, the trauma patient simulator, and the traditional teaching method on the training of outstanding doctoral candidates for the first time. In this study, PTEBL teaching method combined with Caesar can effectively improve students' mastery of traumatic hemostasis skills, and at the same time can make up for the shortcomings of the traditional teaching method, which has promotional significance in STB skills training for outstanding doctoral candidates.

## Abbreviations

STB

Stop The Bleed

PTEBL

problem-, team-, and evidence-based learning

SD

Standard Deviation

# **Declarations**

## **Ethics approval and consent to participate**

The ethics committee of third Xiangya Hospital approved this study (ID: 2021-S078). Students were voluntary to enroll in the research.

## **Consent for publication**

Not applicable.

## **Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## **Competing interests**

The authors declare that they have no competing interests.

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## **Authors' contributions**

JH, SJC and SW were responsible for the design of this study and performed the experiments. JH and CG carried out the study and collected important background information. SYC analyzed/interpreted the results and wrote the manuscript. JL provided assistance for data acquisition, data analysis and statistical analysis. JH and MD were responsible for the review and revision of the manuscript. XT provided the experimental site and materials. All authors have read, revised and approved the manuscript.

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## Tables

Due to technical limitations, Tables are only available as a download in the Supplemental Files section.

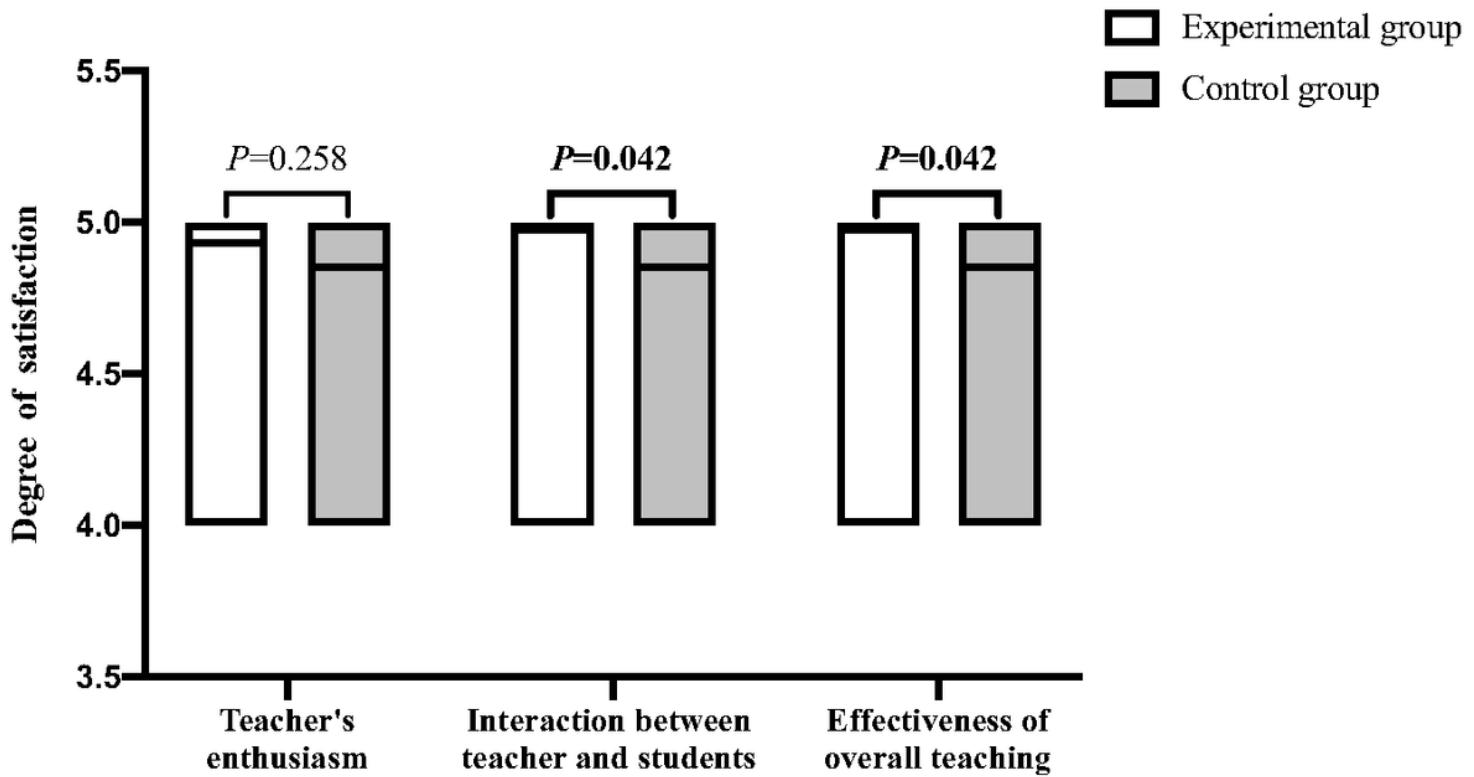
## Figures

### Figure 1

Enrollment, randomization, and protocol of participants.

### Figure 2

Students' approvement of various abilities improvement.



**Figure 3**

Students' satisfaction with the effectiveness of teaching.

**Figure 4**

Correlation heatmap of relevant independent variables. \*: $P<0.05$ ; \*\*: $P<0.01$

## Supplementary Files

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