

A Pilot Study of Team-based Learning in Paediatric Clerkships

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Abstract

Background: Team-based learning (TBL) is widely used in health profession education. However, the use of TBL in paediatric clerkships is rare. In this study, we explore the efficacy and feasibility of TBL in paediatric clerkships. **Methods:** We retrospectively reviewed the TBL course for paediatric clerkships from August to October 2019 at the Children's Hospital, Zhejiang University School of Medicine, Hangzhou, China. The TBL group (with 107 students) was compared to the students from the prior year who learned via case-based discussion (control group with 222 students). The learning outcomes were measured using theoretical exams when the paediatric clerkships ended. The satisfaction with TBL was evaluated by an anonymous questionnaire administered to the TBL group.

Results: The grade point averages before paediatric clerkships in the TBL group (3.58, 3.04-3.96) were similar to those in the control group (3.62, 3.16-4.00) ($p=0.839$). However, the theoretical exam scores in the TBL group (76, 67-82) were significantly higher than those in the control group (72, 64-78) ($p=0.002$). In addition, 92.5% of the students in the TBL group rated their level of satisfaction higher than 90%.

Conclusions: Our study demonstrated that TBL in paediatric clerkships was effective and feasible and that it led to better learning outcomes.

Background

Clerkships are one of the core components of undergraduate medical education(1). During clerkships in various specialties, medical students participate in immersive learning in different departments, including paediatrics. Paediatric teaching and learning have certain features. However, some studies have found that students show lower interest in paediatrics(2). Compared with clerkships in other medical schools (1, 3, 4), our paediatric clerkships are much shorter, only three weeks. Learning and teaching are challenges for both students and teachers. Active learning is known to enhance the effects of learning(5) by improving knowledge acquisition and evoking memories. We seek to change students' learning methods by changing our teaching methodologies.

Team-based learning (TBL) has become popular in health profession education in recent years(6, 7), including in different medical specialties. TBL is a unique and powerful form of small-group learning(8). "It harnesses the power of teams and social learning combined with accountability structures and systematic instructional sequences to let you achieve powerful results"(8). TBL has 4 stages: preparation before class; individual readiness assurance tests; group readiness assurance tests; and application activities, which require students to apply the knowledge from the readiness stage into the "real world"(7). All these stages involve teams working on the same problem and encourage students to learn actively and participate maximally in group discussion. A systematic review of 118 studies(7) showed that 47% explored the practice of TBL in undergraduate education; however, only 2 of those articles focused on paediatrics(7). A recent research has demonstrated that application of TBL in medical education in China is limited(9)

According to the positive findings on TBL in the literature(10-14) and our colleagues' experience, we hypothesized that implementing TBL in paediatric clerkships could improve the effectiveness of undergraduate students' learning of paediatrics. Here, we retrospectively reviewed our students who participated in a paediatric clerkship using TBL in 2019 and compared their outcomes with those of students from the prior year who learned using case-based discussion. We aimed to prove that TBL was effective and feasible in paediatric clerkships according to learners' performance and satisfaction, and teachers' reflection.

Methods

This study was approved by the Ethics Committee of the Children's Hospital, Zhejiang University School of Medicine.

We organized TBL in paediatric clerkships for students who were majoring in clinical medicine from August to October 2019 at the Children's Hospital, Zhejiang University School of Medicine.

Subjects

The students were enrolled in 5-year undergraduate programmes at Zhejiang University School of Medicine. They participated in clerkships in many specialties in their third year, including 3 weeks in paediatrics. Each round of the paediatric clerkship contained approximately 35-40 students according to their rotation plans. We retrospectively reviewed the teaching methods the students experienced and their performance before and after their paediatric clerkships. The student cohort with TBL-based paediatric clerkships (TBL group) was compared with the student cohort from the prior year (control group), with whom case-based discussion was used as the teaching method. The students' grade point averages (GPAs) in their major courses before their paediatric clerkships were reviewed.

Control Group

The paediatric clerkships for the students in the control group included 4-6 case-based discussions within 3 weeks (Table 1). The case-based discussion was a learner-centered learning. The cases used in the discussions were chosen by the students themselves during their clerkships and mainly covered core paediatric topics (Table 1). The topics were not fixed. For each case-based discussion, one student in one group volunteered to do the preparatory work including presenting the case to the group and organizing the discussion. The chosen topics were usually from the cases that the students encountered during the 3-week clerkship. The students would conduct the discussion, including presenting a typical case, asking questions to other group members, and explaining the possible rationale. One teacher would be assigned to a group as an instructor. The teachers' role was mainly to preview the students' preparatory work (including the slides), observe the discussion, and facilitate the discussion if necessary. The groups held their discussions separately.

TBL Group

The paediatric clerkships for students in the TBL group contained 4 modules. The 4 modules were fixed and covered the following paediatric topics: acute gastroenteritis with fluid therapy, neonatal hyperbilirubinemia, pneumonia, and glomerulonephritis/nephritic syndrome (Table 1). The topics chosen in the TBL group depended on the teachers' subspecialties.

The faculty members had attended a TBL fellowship training course or a TBL workshop before the TBL started. Ultimately, 4 teachers participated in the TBL group. Three of those 4 teachers were the same as in the control group, including one teacher who had more than 10 years of teaching experience in paediatrics. Each TBL module was conducted mainly by one paediatric faculty member, and another faculty member would help with the readiness assurance test portion.

The students had no knowledge of TBL before the clerkship. When the paediatric clerkships started, the students received a brief introduction to TBL methods, including how they worked and what students should do in each component. The preparatory materials were assigned 2 days before classes, usually from certain chapters in the textbook or articles. The TBL modules were designed in the "4 Ss" framework (significant problem, same problem, specific choice, and simultaneous reporting) (8). The learning objectives were set to meet the paediatric requirements in the national examination qualifying doctors to practise medicine.

A TBL module began with a closed-book individual readiness assurance test (iRAT) containing 12 multiple-choice questions (MCQs). The iRAT had to be finished in 12 minutes. Those MCQs were based on clinical problems. Students completed the iRAT using a mini-program in the WeChat app. When teachers logged into the mini-program, they could see the iRAT results for each student and each MCQ. During the iRAT, the students did not receive feedback on which were the right answers. Then, the students started the discussion in teams and finished the closed-book team readiness assurance test (tRAT), which included the same questions as the iRAT. The tRAT was conducted using the Immediate Feedback Assessment Technique (IF-AT) via scratch cards or voting cards. The scratch cards were made by our faculty members. The scratch cards would eventually reveal the correct answers to the students and recorded the students' confusion. The voting cards revealed the students' initial opinions and could prompt an immediate discussion. After the tRAT with the discussion, there was a short time for a mini-lecture conducted by the teachers. The teachers would provide feedback and clarification to ensure that the key principles were understood by all the students. The application began with another clinical case. The questions were presented as clinical problems. In addition, the application questions not only covered the key principles addressed in the tRAT but also required the application of other knowledge. After the groups shared their ideas simultaneously, gallery walks began, which allowed groups to cross-examine others and leave comments. The discussion was guided by facilitators, and the groups expressed their thinking. Peer reviews were done via mobile phone after class, using the UT Austin method(8) to obtain descriptive feedback on performance during the TBL module. That feedback would be given to the students after each TBL module. When each module ended, the teacher would assign reading material related to the topics.

Measuring Outcomes

During the TBL practice, the iRAT and tRAT scores would be recorded.

At the end of the paediatric clerkships, all students would be evaluated using a closed-book theoretical exam that consisted of 100 MCQs and had a time limit. The MCQs covered most of the topics on the national examination qualifying doctors to practise medicine required in paediatrics, not just the core topics. The proportions of each topic on the final course exam are showed in the additional file 1. The students in both the control group and the TBL group took the theoretical exam with the same proportions of each topic. MCQs that were used in the readiness assurance tests or prior theoretical exams were not repeated. The percentage and accuracy of the MCQs that were covered by topics discussed in the control group and in the TBL group were reviewed and analysed.

The satisfaction of the students who enrolled in the TBL group was assessed with an anonymous questionnaire when the paediatric clerkships ended. The questions in the questionnaire were answered using a five-point scale, and the response options included strongly agree, agree, neutral, disagree, and strongly disagree. Additionally, an open-ended question was included for students to provide further suggestions or comments on TBL.

Teachers' reflecting: The teachers were interviewed after the teaching activities with the following questions: 1) Do you think TBL was a better way of teaching, compared with case-based discussion? 2) Why do you think of that? 3) Would you prefer to use TBL over case-based discussion in your future teaching activities? Their answers were summarized.

Statistical Analysis

The statistical analyses were conducted using SPSS version 25.0 (IBM, Armonk, New York).

Normally and nonnormally distributed continuous data were presented as the mean \pm standard deviation and the median with the interquartile range (IQR), respectively.

A chi-square test was applied to the categorical variables. The Mann-Whitney test was used for nonnormally distributed data, and the *t* test was used for normally distributed data. Significance was considered as a *p* value <0.05.

Results

In the 2018-2019 academic year, 222 third-year students (control group) participated in paediatric clerkships using the case-based discussion teaching method at the Children's Hospital, Zhejiang University School of Medicine. In the 2019-2020 academic year, 107 third-year students (TBL group) participated in paediatric clerkships using TBL in the same hospital. The students in the TBL group were not familiar with TBL before this experience. The demographics and the theoretical exam scores of the two groups are given in Table 2. The GPAs in major courses before the paediatric clerkships were similar

in the two groups ($p=0.839$). However, the theoretical test scores at the end of paediatric clerkship in the TBL group were higher than those in the control group ($p=0.002$). Furthermore, for the part of the test containing the topics that were covered in the teaching activities, the control group had a higher percentage than the TBL group (38% vs 26%), but less accuracy ($p=0.002$) (Table 2). Among all the topics, “pneumonia” was the only one discussed in every round of the paediatric clerkship, in both the control group and the TBL group. The TBL group had greater accuracy on the “pneumonia” portion of the test than the control group (80.0% vs 66.7%, $p=0.000$) (Table 2).

Learning Process in the TBL Group

During the 3-week clerkships in paediatrics, the students in the TBL group completed 4 TBL modules. Their performances were recorded as their iRAT and tRAT scores (Table 3). In each module, the tRAT scores were all higher than the iRAT scores ($p<0.05$).

Students' Satisfaction

A total of 99 (92.5%) students in the TBL group responded to the anonymous questionnaire. Overall, more than 90% of the students gave positive feedback on TBL: 97.0% felt they learned better with TBL, and that their abilities (learning motivation, self-directed learning, collaboration, data analysis, expression and communication) improved (97.0%, 98.0%, 95.0%, 97.0%, and 93.0%, respectively), 97.0% of the students received help and feedback during TBL, 98% of them thought TBL was effective, and 91.0% of them preferred TBL. Further details are presented in Table 4.

The students provided many suggestions for TBL. Some students proposed more TBL modules or an arrangement that covered more core topics. Some students suggested that it would be better if the teacher gave a summary after the discussions. A few students desired more opportunities to express themselves. Two students thought it was slightly rushed to learn 4 modules in 3 weeks. One student complained that one team member was not devoted to the class.

Teachers' Reflecting:

All 4 teachers agreed that TBL was better than case-based discussion and would prefer to use TBL more in the future. The 4 teacher authors reflection were as follows: Teacher one: The students in the TBL group participated more in class, and I felt they were willing to learn more when the classes were over. The accountable learning process gave me clear feedback on the students' learning progress: I could easily point out the weak points of any students, and ask specific questions to facilitate the discussion. Teacher two: The classes in the TBL group were more active, and the students were highly involved during the TBL modules. Teacher three: During the discussion time in the TBL group, the students were easily supported by other team members, which made the learning was effective. Additionally, I had an experience of taking over a TBL class for an absent teacher. Although I wasn't familiar with that content in the TBL module, similar steps and a well-prepared teaching plan made it much easier than other teaching methods. Teacher four: I felt the self-learning in the TBL group was more improved, and the

students preferred to work in a team after the classes. Besides, the structured TBL modules made the discussion more effective and focused. During the discussion in the TBLs, all the group members were working on the same problem.

Discussion

This study used TBL in the paediatric clerkships of medical undergraduate students. Our research demonstrated that through the use of TBL, medical students could obtain more theoretical knowledge than they did with the case-based discussion method. The learning progress could be quantified based on the TBL components. Students were satisfied with TBL even though they had never experienced it before.

Why did TBL work in our 3-week paediatric clerkships? In our opinion, its success might be due to the teachers, the students, and TBL itself. The teacher was one of the key elements in the teaching activities. In our practice, the teachers were well trained before TBL was implemented as described in the Methods section. In addition, we had one teacher who was experienced in paediatric teaching. These factors made our faculty members well prepared for TBL. Of other studies describing characteristics of TBL facilitators(7), only a few mention the facilitators' training or experience before implementing TBL. However, according to Michaelsen's table describing the elements of TBL(7), teachers played an important role in "teacher decision" and "individual characteristics (teacher attitudes)". Thus, the enhanced TBL training that our teachers received before implementing TBL may be one factor contributing to the better outcome in the TBL group.

Students were another impacting factor in our teaching activities. Before the paediatric clerkships started, the students in the control group had the same GPA in their major courses and a similar sex ratio to the students in the TBL group. The students in both groups shared the same textbooks. Case-based discussion and TBL were both learner-centered learning methods, and the students dominated the discussions and were encouraged to learn actively. However, the results showed that the groups achieved different results. In the TBL group, every student did the preparatory work instead of just one student in the control group. During the discussions, the students in the TBL group showed more interest because they were addressing on the same question. In contrast, in the control group, the students who volunteered to do the preparatory work usually did the most job, while the others' preparatory work could not be measured. The discussion in the control group might not have been that effective because of the unbalanced preparation among group members. In the teachers' reflection, 3 of 4 stated the students in the TBL group were more "active" and "involved" and that they "participated". One teacher stated that the students' self-learning improved in the TBL group, while most of the students in the TBL group self-reported that their motivation for learning increased and self-learning improved. In the results regarding the analysis of the theoretical test, the control group covered more topics, but the accuracy of the topics covered parts was lower than in the TBL group. Overall, the TBL group did much better than the control group on the theoretical exam, achieving higher scores. This indicated that the students could learn better

with TBL, even if they had not previously experienced TBL. Our findings here are consisted of other TBL practices in paediatric(10, 14) and non-paediatric fields(15, 16).

TBL itself was another factor that may have caused the different learning outcomes. TBL is a structural learning method. The iRATs and tRATs made the students accountable for their readiness. The RAT results could serve as feedback for the students, and also informed the teachers of any “weak point” or “confusing part”, which made the discussions between groups more powerful and effective. The teachers’ reflection in our practice might support this theory. Furthermore, by working in smaller sized groups (5-7 students per group in the TBL group compared to 8-10 persons per group in the control group), the TBL students had more opportunities to share their thoughts. When teams debated with each other, they might clarify items and obtain a deeper understanding. This learning process may have been more effective because it was learning from peers, as addressed in another study(17).

In addition, we found that the TBL group required fewer classrooms than the control group. The teachers in our practice liked TBL more, possibly because it involved less teaching time, was more effective at helping students learn or allowed teachers to easily taking over a class for each other.

Nevertheless, this study had limitations. As the learning and teaching methods changed, the methods of measuring learning outcomes did not change. The topics used in the two groups were not exactly the same, which might have influenced on the teaching effect. The topics chosen in the TBL group was influenced by the teachers because it was our first attempt at TBL teaching. As more TBL modules are used in paediatric clerkships, more topics can be selected by the students in the future. The theoretical test scores might only show how knowledge was recalled or applied. Other abilities that might be improved through TBL, such as teamwork and communication, could not be properly assessed in our study. In terms of learning, the theoretical exams at the end of the paediatric clerkships only tested short-term outcomes. We did not explore the long-term effects. Other recent studies have presented the opposite results(10, 14). More studies on the long-term outcomes of TBL are needed. Furthermore, the purpose of a clerkship should not only be theoretical knowledge but also clinical competency. Some more objective metrics are needed in clerkships to evaluate students’ performance. In that way, we might be able to see more fully how TBL influences paediatric clerkships.

Conclusion

In this study, we showed the efficacy and feasibility of TBL in paediatric clerkships, even within a short time. Students could master the knowledge and improve self-learning through team cooperation. The quantified learning process provided immediate feedback for students and improved the efficacy of the discussions, which were facilitated by teachers.

Abbreviations

TBL: team-based learning

GPA: grade point average

iRAT: individual readiness assurance test

MCQ: multiple-choice question

tRAT: team readiness assurance test

IF-AT: Immediate Feedback Assessment Technique

Declarations

Ethics approval: This study was approved by the Ethics Committee of the Children's Hospital, Zhejiang University School of Medicine (No.2019-IRB-153). All procedures performed in this study involving human participants followed the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

Consent for publication: Not applicable

Availability of data and materials: All data generated or analysed during this study are included in this published article and available from the corresponding author upon reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: LX, YZ, ZC, and QS designed the research. LX, YC, YX, and JW conducted the research. LX and YZ collected the data. LX analysed the data. YZ checked all of the data. LX was a major contributor in writing the manuscript. ZC and QS had the primary responsibility for the final content. All the authors offered critical comments and read and approved the final manuscript.

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Tables

Table 1 Comparison the setting of the control group and the team-based learning group in a paediatric clerkship

	Control group	TBL group
Duration	3 weeks	3 weeks
Number of students (persons)	35-37	35-37
Groups setting	Divided into 4 groups with 8-10 students in each group	Divided into 6 groups with 5-7 students in each group
Topics	Pneumonia, asthma, gastroenteritis, cholestasis, Kawasaki disease, congenital heart disease, IM, HSP, DKA, precocious puberty, epilepsy, meningitis.	Pneumonia, gastroenteritis with fluid therapy*, neonatal hyperbilirubinemia, glomerulonephritis/nephritic syndrome
Topics for each student	4-6	4
Time for students' preparing before class	Not measured	2 hours
Activities in class	1 group contained 8-10 students held discussion every time	6 groups were in class together, in TBL ways
Class hours for each student	4-9 hours for 4-6 cases	12 hours
Occupied time of classrooms	16-36 hours	12 hours
Number of teachers (persons)	4	4
Time for each teacher facilitating work in class	4-9 hours	4.5 hours

TBL: Team-based learning, IM: Infectious mononucleosis, HSP: Henoch-Schonlein purpura, DKA: diabetic ketoacidosis

*: fluid therapy was included in the gastroenteritis module in TBL group while it was instructed as mini-lecture in the control group.

Table 2 Demographics and test results for students enrolled in the cohorts

	Control group	TBL group	<i>P</i> value
Number of students	222	107	
Male (%)	124 (55.9)	71 (66.4)	0.069
GPA [#]			0.839
Median	3.62	3.58	
IQR	3.16-4.00	3.04-3.96	
Test scores at end of paediatric clerkship			0.002
Median	72	76	
IQR	64-78	67-82	
Proportions of the topics covered in the test	38%	26%	
Accuracy of the topics covered in the test			0.001
Median	76.2%	80.8%	
IQR	67.7%-83.3%	73.1%-88.5%	
The proportion of the topic “pneumonia” in the test	9%	5%	
Accuracy of the topic “pneumonia” in the test			0.000
Median	66.7%	80.0%	
IQR	58.3%-83.3%	60.0%-100.0%	

TBL: Team-based learning; GPA: grade point average; IQR: Interquartile range

[#]: GPA here was counted from major courses before pediatric clerkship

Table 3 Accuracy of readiness assurance test in each module

	iRAT	tRAT	<i>P</i> value
Module 1	0.50 (0.33-0.58)	0.83 (0.83-0.92)	0.000
Module 2	0.50 (0.42-0.67)	0.79 (0.67-0.83)	0.000
Module 3	0.58 (0.42-0.67)	0.83 (0.75-0.92)	0.000
Module 4	0.58 (0.72-0.75)	0.92 (0.83-1.00)	0.000

iRAT: individual readiness assurance test; tRAT: team readiness assurance test.

Table 4 Questionnaire results of students’ satisfaction (n=99)

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
learning better with TBL	63 (63.6%)	33 (33.3%)	3 (3.0%)	0	0
Increasing my motivation for learning	61 (61.6%)	35 (35.4)	3 (3.0%)	0	0
TBL enhanced my ability of self-directed learning	63 (63.6%)	34 (34.3%)	2 (2.0%)	0	0
Promoting collaboration	55 (55.6%)	39(39.4%)	4(4.0%)	1(1.0%)	0
Developing the ability to analysis and sum up the data	53 (53.5%)	43 (43.4%)	3 (3.0%)	0	0
Expressing and communicating better	45 (45.5%)	47 (47.5%)	7 (7.1%)	0	0
Getting feedback and help in time	55 (55.6%)	41(41.4%)	3(3.0%)	0	0
Having fun in TBL	56(56.6%)	38(38.4%)	4(4.0%)	1(1.0%)	0
TBL was effective	60(60.6%)	37(37.4%)	2(2.0%)	0	0
Preferring TBL more than traditional way	54(54.5%)	36(36.4%)	8(8.1%)	1(1.0%)	0

TBL: Team-based learning

Supplementary Files

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