Author's response to reviews

Title: Evaluating a hybrid team-based and lecture-based learning method for neurology clerkship in China

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Dear editors and reviewers,

Thank you very much for your precious time to review the paper, detailed explanation of the questions, and kind suggestions for improvements!

We have studied the questions and modified the manuscript accordingly. Each question and its answer are listed below in Section Answers. Thanks again for your time to follow up with the review!

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Answers

[Suggestion 1] Please consider beginning the discussion with a brief summary of the main study findings before launching into speculation about why there are differences between the groups.

[Change 1] A paragraph is added to the beginning of the discussion to summarize the main study findings. Besides, the first sentence of the next paragraph is replaced with a question: “Why did the two learning methods involving LBL lead to better practice test score?”

[Suggestion 2] Page 12 - The end of the first paragraph of the discussion beginning "students in the LBL group tend to learn passively etc" down to "and they less concentrate [sic] in the classroom. It is unclear if this is reporting anecdotal evidence from the students in the current study (in which case it needs to be supported by a method and data or stated as anecdotal impressions) or if it is reporting other studies - in which case it needs a reference. (not also that it should read "and they concentrate less in the classroom"
[Change 2] Thanks for pointing this out. We should have clearly stated that as anecdotal impressions. The sentence is changed to: “for instance, during the clerkship we were impressed that the students in the LBL group tended to learn passively without proactive preparation before classes or review after classes. Besides, we also felt that they were less able to concentrate in the classroom and less motivated to take advantage of various learning resources.”

[Suggestion 3] Page 13, last paragraph - the following sentences don't make sense. "Nonetheless, we realized several disadvantages of TBL in the practice. Firstly, we have similar experiences as described in [25]." I think the problem is just grammatical. It is not acceptable to write "as described in [25]. The citation cannot be used instead of a word. It should read something like "as previously described [25]. This happens a few times during the manuscript.

[Change 3] Thanks for pointing this out. “As described in [25]” is changed to “as previously described [25].” Another sentence in Page 7 is changed too: “TBL was conducted in three phases as specified in [22]” is changed to “Following a well-established procedure [22], TBL was conducted in three phases.”

[Suggestion 4] Conclusion - The conclusions should not be a summary of the background, methods, and results (this goes in the abstract) but what you can conclude about TBL/ LBL within the context of your study.

[Change 4] Thanks! The conclusion is rewritten.

[Suggestion 5] There are a considerable number of typographical and grammatical errors throughout the manuscript that required proofing. Often "learning outcomes" is written in singular tense when it should be plural.

[Change 5] Thanks for giving us the opportunity to change these errors. We've carefully proofread the manuscript for several times, fixed and tried to improve many sentences. For example, the tense of “learning outcome” and “score” are corrected, some “a/the” issues are found and fixed, and many sentences are rewritten. Since the changes are too many to be described one by one (there are 188 revisions according to Word report), we include the screenshots of them shown as below. The red words with underscore are newly added words, while the red words with a line across the center are deleted words.
Background

Neurology is known to be complex, abstract and difficult for students to learn. Meanwhile, a good learning method for neurology clerkship training is required to help students quickly develop strong clinical thinking as well as problem solving skills quickly. Both the traditional Lecture-Based Learning (LBL) and the relatively new Team-Based Learning (TBL) methods have inherent strength and drawbacks weakness when being applied to neurology clerkship education. However, the strength of each method may cover complement the shortage weakness of the other. So we think complementing combining TBL with LBL is an effective way to yield better learning outcomes than applying TBL or LBL alone. In this research we proposed a hybrid method (TBL+LBL) and designed an experiment to compare its learning outcomes with those of pure LBL and pure TBL.

Method

127 fourth-year medical students attended a two-week neurology clerkship program organized by the Department of Neurology, SUN Yat-Sen Memorial Hospital. All of the students were from Grade 2007, Department of Clinical Medicine, Zhongshan School of Medicine, SUN Yat-Sen University (SYSU). These students were randomly assigned to one of three groups: Group A (TBL+LBL, with 41 students), Group B (LBL, with 43 students), and Group C (TBL, with 43 students). The learning outcomes were evaluated by a questionnaire and two tests covering basic knowledge of neurology and clinical practice.

Results

The practice test scores of Group A (TBL+LBL) were similar to those of Group B (LBL) but significantly higher than those of Group C (TBL). The theory test scores and the total scores of Group A were significantly higher than those of Group B (LBL) and Group C (TBL). In addition, 100% of the students in Group A were satisfied with TBL+LBL.
Conclusions

The groups with lecture-based learning involved performed better in the practice test, and applying both TBL and LBL resulted in better theory test scores and total scores than applying TBL or LBL alone. The hybrid method was also widely accepted by the students.

Background

Dealing with large number of frequent and diversified nervous system disorders in clinical situations, Neurology is often perceived by students as overly complex, abstract, and far more difficult than other disciplines [1-3]. At the same time, bridging medical theory and practice, clerkship is one of the crucial stages in neurology education when the clinical reasoning and operating skills of students are substantially trained [4]. However, traditional Lecture-Based Learning (LBL) widely used for neurology clerkship education often leads to unsatisfactory learning outcomes, as medical students passively being applied to neurology clerkship education. TBL relies on the students to prepare and do the homework by themselves but the neurology course materials are usually very difficult for students to understand, and even harder for them to build a clear and well-organized knowledge hierarchy. Meanwhile some research also found that TBL may
According to the literature and our experiences, LBL excels in breaking down difficult subjects, logically organizing them in a clear hierarchy, and presenting them systematically. On the other hand, TBL excels in motivating students to learn proactively and promoting team collaborations. The strength of each method may complement the shortage weakness of the other. So we think complementing combining TBL with LBL is an effective way to yield better learning outcomes than applying TBL or LBL alone. In this research, we designed and proposed a new hybrid LBL and TBL method (TBL+LBL) for neurology clerkship education. In addition, we designed an experiment to teach three groups of students with LBL, TBL, and TBL+LBL respectively. Then we compared the theory and practice test scores of these three groups at the end of the clerkship to evaluate the advantages learning outcomes of TBL+LBL. Besides, a questionnaire was completed by the students in TBL and TBL+LBL groups to evaluate their satisfaction levels.

Methods

The neurology clerkship under study was organized by the Department of Neurology, SUN Yat-Sen Memorial Hospital. It belonged to a five-year undergraduate program for the students majoring in Clinical Medicine. The fourth year of the program was dedicated to clerkship of many medical specialties, in which two weeks were for neurology. The whole 127-student class of Grade 2007 from the Department of Clinical Medicine, Zhongshan School of Medicine, SUN Yat-Sen University (SYSU)SYSU participated in this neurology clerkship.

Though the students had the right not to participate in this study, all of the students chose to join. By drawing lots, the students were randomly assigned to one of three groups by drawing lots: Group A (TBL+LBL, with 41 students including 22 men and 19 women), Group B (LBL, with 43 students including 23 men and 20 women), and Group C (TBL, with 43 students including 21 men and 22 women). Before the clerkship started, all of the students had learnt the related courses. No significant difference was observed among the
LBL Method

The curriculum consisted of many case studies that covered several the following important neurology courses, such as: Physical Examination of Nervous System, Nervous System Qualitative and Positioning Diagnosis Principle, Principles for Differential Diagnosis, Cranial Neuropathy and Peripheral Neuropathy, Cerebrovascular Diseases, Diseases of Spinal Cord, and Peripheral Nervous System Diseases. For each type of cases, all of the students from Group B were led into a big room dedicated for teaching in the Department of Neurology of the hospital. The patients were temporarily moved to this room before the demonstration. The instructor first demonstrated the process of medical history inquiry and physical examination, and then provided the examination results to the students as a reference. After the demonstration, the instructor gave lectures to explain the clinical characteristics of the cases, the special examination methods for the cases, the key points of disease identification, diagnosis and treatment, and as well as the fundamental concepts for many common neurological diseases. These common neurological diseases including cerebrovascular diseases, diseases of spinal cord, and peripheral nervous system diseases. Subsequently, the students were required to identify the characteristics of each case and propose diagnosis and treatment plan accordingly, before the instructor summarized and drew conclusions.
TBL Method

Group C participated in the second clerkship session. Compared with Group B, the instructor, the curriculum, the learning objectives, and the time spent with the instructor were all the same, except that the learning methods were different. Similar to Group B, at the beginning of each case study, the instructor conducted a similar demonstrations. Note that the patients being diagnosed for different groups were different, since the majority of the patients usually stayed for less than two weeks in the hospital, and thus it was difficult to have the same patients diagnosed in different two-week sessions. Nevertheless, for the same case, we carefully chose the patients so that their disease types, symptoms, and diagnosis results were similar, in order to minimize the difference in learning experiences. After the demonstration, instead of receiving lectures as Group B, the students in Group C studied the same topics in a team-based way as described below.

Group C were divided into seven teams with each comprising five to seven students. Following a well-established procedure [22], TBL was conducted in three phases as specified in [22]. Phase One was a preparatory phase. The students first got familiar with the course objectives, requirements and the case information given by the instructor prior to the class. Based on these, they carried out the study through various ways
The questions focused on disease identification, diagnosis, and treatment choice. Intra-team discussion was allowed, aiming at providing a final answer for the team. At first only intra-team discussions were allowed, through which each team was required to get its own answers. Next, inter-team discussions and debates started, eventually reaching an answer accepted by all the students. Next, inter-team discussions and debates were carried out to reach a set of answers accepted by all of the students. At the end of the discussions, after the instructor had evaluated both the answers and the discussion results, feedback was provided accordingly to help the students achieve clearer as well as more systematic understanding of the knowledge and skills. Afterwards the instructor evaluated the discussions and the answers, and then provided feedback accordingly to help the students achieve clearer and more systematic understanding of the knowledge and the skills.

Phase Three was the application of course concepts. Considering the fact that the students had acquired the necessary knowledge and skills through Phase One and Phase Two, five to eight complex questions were given. The instructor gave five to eight complex questions to them. The questions required them to summarize, analyze and reason carefully, based on the knowledge they had learnt and the facts they had observed. Again, after the intra-team study and discussion had ended with a team answer reached, inter-team discussions and debates were held among the teams holding different opinions. Similar to the process in Phase Two, intra-team studies and discussions took place at first. Afterwards inter-team discussions and debates were carried out among the teams holding different opinions.

The instructor then commented on each group's discussion results, and summarized the main topics of the course. As the last step, the students were encouraged to evaluate each other based on their performance, including motivation, abilities of analysis as well as expression skills. In terms of motivation, analytical skill and expression skill.
TBL+LBL Method

Both TBL and LBL were employed for Group A. During the first week Group A received lecture-based teaching which covered complex and systematic courses such as Physical Examination of Nervous System, Nervous System Qualitative and Positioning Diagnosis Principle, Principles for Differential Diagnosis, as well as Cranial Neuropathy and

Performance and Satisfaction Evaluation

At the end of the clerkship, the performance of each student was evaluated with both theory test and practice test two tests: a theory test and a practice test. The test contents for the three groups were exactly the same. They are well-established in the medical program. Well established in the medical program, the test content for the three groups was exactly the same. The theory test mainly evaluated the students' understanding of the fundamental concepts, the causes, the characteristics, the diagnosis and treatment for the diseases covered in the clerkship. The questions in the test were carefully selected from the standard question library pool of SYSU. Note that this test and the pre-test before the clerkship were of different difficulty levels so their scores were not comparable. Note that the scores of this test were not comparable with those of the pre-test before the clerkship, since the difficulty of the tests was different. The practice test mainly evaluated the students' proficiency of conducting disease history inquiry, physical examination, and medical record writing. Each test student was rated with a hundred-mark weighted total score, 40% of which was based on the practice test score and 60% was based on the theory test score. The total scores were required to be reported to SYSU. The weighting
followed the teaching guidelines of SYSU, and had been used consistently for many years. In addition to the tests, for Group A and Group C anonymous questionnaires were given to evaluate their satisfaction with TBL in 4-point scale: excellent, good, fair, and poor, for various aspects. The questionnaires were collected at the scene. In addition to the tests, Group A and Group C were required to take a questionnaire to evaluate their satisfaction with TBL. The satisfaction was evaluated for various aspects in four-point scale: excellent, good, fair, and poor. The answers were collected at the scene.

Data Analysis

Comparison at the end of the clerkship

Analysis of the test scores at the end of the clerkship is shown in Table 2. Group A achieved the highest scores. Group A and Group B achieved similar practice test scores but Group A achieved higher theory test and total scores ($P < 0.05$). Compared with Group C, Group A had higher score in all aspects ($P < 0.05$). Comparing Group B and Group C, no significant difference was observed in terms of theory test score and total score. However, Group C has had much lower practice test score than Group B.

Questionnaire

The questionnaire response rate of the questionnaire was 100%. All of the 84 students from Group A and Group C returned their answers. The content of the questionnaire and
of the topics. The students agreed that LBL could better help students learn the relatively complex and non-intuitive parts than TBL. By contrast, TBL+LBL achieved 100% satisfaction, as shown in Table 3.

**Discussion**

In summary, the experiment led to three findings. Firstly, the practice test scores of Group A (TBL+LBL) were similar to those of Group B (LBL) but significantly higher than those of Group C (TBL). In other words, the groups with lecture-based learning involved performed better in the practice test. Secondly, the theory test scores and the total scores of Group A were significantly higher than those of Group B (LBL) and Group C (TBL). Lastly, the questionnaire showed that the hybrid method was widely accepted by the students.

Our experiments demonstrated that pure TBL led to worse clinical practice test score than the other two learning methods involving LBL. Why did the two learning methods involving LBL lead to better practice test scores? The reason is two-fold. Firstly, LBL is suitable for neurology which is known to be less accessible and user friendly than other specialties [2]. With LBL, the lectures break down the difficult subjects of neurology into small topics, logically organize them in a relatively clear hierarchy, and present them systematically. Hence it is easier for students to memorize and understand. LBL also helps the students connect and transform the simple and abstract knowledge into a concrete, logical, and comprehensive picture. Secondly, LBL lays emphasis on developing fundamental clinical skills such as effective and accurate disease history inquiry, comprehensive nervous system examination, proper and formal medical
record writing, as well as good communication between doctors and patients. These are all essential skills in clinical practice. Therefore, despite TBL offers many advantages, traditional LBL is still indispensable for neurology clerkship education. On the other hand, LBL has disadvantages too. For instance, students in the LBL group tend to learn passively without pro-active preparation before classes or review after classes. Besides, students are often less motivated to take advantage of various learning resources and they less concentrate in the classroom. For instance, in the study we were impressed that the students in the LBL group tended to learn passively without pro-active preparation before classes or review after classes. Besides, we felt that they were less able to concentrate in the classroom and less motivated to take advantage of various learning resources. Research Some research also found that LBL was insufficient for the culture of clinical thinking [21] and team-work spirit [9,11].

The disadvantages of LBL can be addressed effectively by complementing it with TBL. Combining LBL with TBL is an effectively way to overcome the disadvantages of LBL. TBL lays stress on encouraging students to learn pro-actively, as well as to improve analytical and problem solving skills in clinical situations. Moreover, TBL is known to be beneficial for promoting team-work and collaboration among students [9,14,22]. In the meantime, TBL implicitly enhances the students' abilities of bibliographic retrieval, logical reasoning, and oral presentation. These key abilities are extensively demanded in clinical practice but often less trained practiced with LBL. The questionnaire results revealed that the majority of the students accepted TBL and considered agreed that TBL could result in active classroom atmosphere, enhance learning motivation, strengthen team-work spirit, as well as improve clinical problem solving skills. Furthermore,
instructors can improve themselves in the TBL process. The reason is as follows. For TBL to be successful they need to prepare questions with certain difficulty according to the course content and the specific clinical diagnosis and treatment processes. This motivates the instructors to improve themselves in order to have not only solid knowledge and clinical skills but also organizing and managing skills. Besides, instructors can also gain inspirations from team discussions. In summary, teaching and learning can help each other [23, 24]. Nonetheless, we realized several disadvantages of TBL in the practice. Firstly, we have similar experiences as previously described [25], described in [25]. Compared with LBL, TBL is less effective for the students with weak self-studying ability. This leads to bigger variation in learning outcomes among the students. Secondly, for TBL to achieve better learning outcomes than LBL, students effective discussions. As an example, without receiving as much systematic training in the classroom as with LBL, Group C (TBL) did not achieve significantly better scores than Group B, as shown in Table 2. Lastly, compared with LBL, students in-TBL groups with TBL often have less capability to learn knowledge in a systematic way. The knowledge learnt with TBL tends to be not as deep or as comprehensive as with LBL. For instance, based on the feedback from the students in the TBL group, they tended to miss some important topics.
There were two limitations in this research. Firstly, since no questionnaire has been done for the LBL group, the authors do not know what the LBL group thought of their teaching, so no comparisons can be made on student perspective. When we carried on the study, since TBL was a very new learning method, we mainly focused on exploring its benefits but ignored the importance of comparing it with LBL in terms of the students' satisfaction level with traditional LBL. Though the results of the questionnaire indicated that Group A and Group C had experienced increased motivation and teamwork spirit, the base of comparison was their past experiences with lecture-based learning for other subjects. Without comparison with the satisfaction of Group B, the results of the questionnaire were less convincing than with it. Secondly, there may be possibility of bias in student self-reports on the evaluation questionnaires. To minimize this, the questionnaires were sent to the students only after the theory test and the practice test had finished. We will improve these in further research.
Conclusions

Clerkship is the starting point of clinical experiences for medical students. In neurology education, clerkship is an important stage to train them as a qualified doctor, in that it provides an opportunity to apply the theory and knowledge learnt in classes to clinical practice, to develop strong clinical thinking, and to improve analytical as well as problem-solving skills. Being overly complex and abstract while requiring concrete clinical thinking and problem solving skills, neurology is so difficult to learn that neither TBL nor LBL produces satisfactory learning outcomes by itself. An experiment was done to compare the theory and practice test scores of LBL, TBL, and TBL+LBL groups who used the same curriculum, had the same instructor and learning objectives, spent the same time with the instructor, and diagnosed similar patients. The results showed that the groups with lecture-based learning involved performed better in practice test, and applying both TBL and LBL resulted in better theory test score than applying TBL or LBL alone. The hybrid method was also widely accepted by the students. We believe the proposed method can be applied to teaching other important but difficult topics similar to neurology.

In this study, compared with TBL, LBL led to improvement in the practice test scores. The two groups who had received lecture-based teaching for the complex and systematic courses performed better in the practice test than the group who had not. In addition, applying both TBL and LBL resulted in better theory test scores and total scores than applying TBL or LBL alone. Besides, the questionnaire results showed that the hybrid TBL+LBL method was widely accepted by the students.
### Table 1. Base level of the students in the three groups (x ± s)

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of students (n)</th>
<th>Sex ratio (male/female)</th>
<th>Age</th>
<th>Theory test scores before the clerkship</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>41*</td>
<td>22/19*</td>
<td>21.4 ± 2.81*</td>
<td>83.9 ± 8.33*</td>
</tr>
<tr>
<td>B</td>
<td>43</td>
<td>23/20</td>
<td>21.6 ± 2.25</td>
<td>84.2 ± 7.50</td>
</tr>
<tr>
<td>C</td>
<td>43</td>
<td>21/22</td>
<td>22.0 ± 1.76</td>
<td>84.7 ± 6.97</td>
</tr>
</tbody>
</table>

* Compared with Group B and C, P > 0.05

### Table 2. Test scores of the students in the three groups at the end of the clerkship (x ± s)

| Group | Number of students (n) | Practice test scores | Theory test scores | Total scores |
|-------|------------------------|----------------------|-------------------|--------------|-------------|
| A     | 41*                    |                      |                   |              |
| B     | 43                     |                      |                   |              |
| C     | 43                     |                      |                   |              |