—Report on Experiments and Clinical Cases—

Team-based Learning Using an Audience Response System: A Possible New Strategy for Interactive Medical Education

Terumichi Fujikura[1,2,11], Toshiyuki Takeshita[3,11], Hiroshi Homma[4,11], Kouji Adachi[5,11], Koichi Miyake[6,11], Mitsuhiro Kudo[7,11], Takami Takizawa[8,11], Hiroshi Nagayama[9,11] and Keiko Hirakawa[10,11]

[1]Academic Quality and Development Office, Nippon Medical School
[2]Department of Head & Neck and Sensory Organ Science, Graduate School of Medicine, Nippon Medical School
[3]Division of Reproductive Medicine, Perinatology and Gynecologic Oncology, Graduate School of Medicine, Nippon Medical School
[4]Division of Cardiology, Hepatology, Geriatrics, and Integrated Medicine, Department of Internal Medicine, Graduate School of Medicine, Nippon Medical School
[5]Department of Neurosurgery, Graduate School of Medicine, Nippon Medical School
[6]Department of Biochemistry and Molecular Biology, and Division of Gene Therapy Research Center for Advanced Medical Technology, Nippon Medical School
[7]Department of Pathology and Integrative Oncological Pathology, Nippon Medical School
[8]Department of Molecular Medicine and Anatomy, Nippon Medical School
[9]Department of Neurological, Nephrological and Rheumatological Sciences, Graduate School of Medicine, Nippon Medical School
[10]Department of Legal Medicine, Nippon Medical School
[11]Small Group Learning Working Committee, Nippon Medical School

Abstract

Following the "Guidelines for reporting TBL" by Haidet et al, we report on a team-based learning (TBL) course we adopted for our 4th-year students in 2011. Our TBL course is a modified version of the one suggested in the guidelines, but its structure generally follows the core elements described therein. Using an audience response system (ARS), we were able to obtain individual and group readiness assurance test scores immediately and give instant feedback to the students. Instructors were thus able to monitor students' understanding in real time and so appreciated the system, which supports interactive classes even in large classrooms. However, TBL is teacher-oriented, and students were less appreciative of ARS, because they recognized that it could be easily used for grading. Nevertheless, we believe that a combination of TBL, and problem-based learning in a mature design can improve both motivation and understanding among learners.
(J Nippon Med Sch 2013; 80: 63–69)

Key words: team-based learning, audience response system, problem-based learning, interactive classes

Correspondence to Terumichi Fujikura, Academic Quality and Development Office, Nippon Medical School, 1–1–5 Sendagi, Bunkyo-ku, Tokyo 113–8602, Japan
E-mail: teru-fujik@nms.ac.jp
Journal Website (http://www.nms.ac.jp/jnms/)

Introduction

Team-based learning (TBL) is an instructional strategy developed in the business school environment in the early 1990s by Michaelsen[1,2]. Combining independent out-of-class preparation for in-class discussion in small groups, it is an approach that has been successfully adopted by many medical educators[3-7]. Because the method can be implemented in various ways to target learners at different levels of knowledge/understanding, it can be difficult to understand and compare the usefulness of different examples of TBL among numerous reports. Haidet et al. solved this problem by establishing guidelines for reporting TBL activities in the medical education literature[3].

TBL is different from problem-based learning (PBL) and other small-group approaches in that large numbers of instructors and rooms are not needed. TBL can thus be used to replace or complement lecture-based courses or curricula.

PBL tutorials have been used for 4th-year students at our institution since 1999, and in 2011, we started a PBL course for the 2nd- and 3rd-year students and a TBL course for the 4th-year students. The modified structure of the TBL course at Nippon Medical School (NMS) is shown in **Figure 1**.

In this article, we describe our TBL course according to the guidelines of Haidet et al[3], using the results of readiness assurance test (RAT) scores and a questionnaire survey of students and instructors to evaluate the course. The results led us to consider using TBL across our whole undergraduate medical program.

Subjects and Methods

1. TBL Implementation

TBL implementation is described according to the "Guidelines for reporting TBL" of Haidet et al (**Table 1**). In 2011, the 105 4th-year students at NMS participated in 15 TBL sessions. Twenty instructors were involved in the course, all of whom had attended an NMS faculty development workshop on TBL. The topics for the TBL sessions were chosen from areas of clinical medicine not covered in PBL classes, such as pediatrics, gynecology, otorhinolaryngology, and acute medicine. In class, the students first took the individual RAT (IRAT) using an audience response system (ARS) (IC Brains Co., Ltd., Tokyo, Japan, and Terada Lenon Co., Ltd., Tokyo Japan). They then had an intra-team discussion about the test, after which they took the

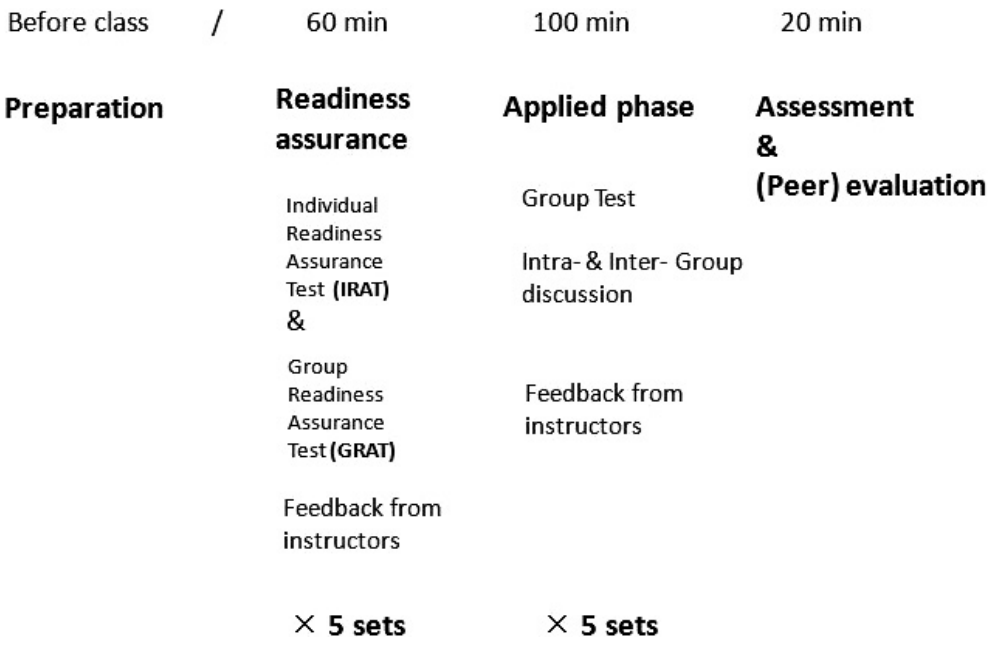

Fig. 1 Modified design of TBL course structure at Nippon Medical School

Table 1 TBL implementation

1. General context and scope of the TBL implementation	One hundred five 4th-year students participated in 15 TBL sessions in teams of 5 to 6 members. All students had previous experiences of group work through PBL courses. They were given a simple modified TBL session for orientation purposes. The TBL course was composed of 15 single sessions of 180 minutes each, which took place in a large classroom equipped with an audience response system. Objectives: To review the knowledge students had accumulated through traditional lectures and to develop their clinical thinking skills before they undertook clinical clerkships.
2. Design decisions specific to the seven core elements of TBL	
1) Team formation	Groups were balanced in terms of sex and the academic achievements of the members. Sorting process was transparent to students. All students could be assumed to have gained some previous knowledge of the TBL course contents via the traditional lectures they had taken.
2) Readiness assurance tests (RATs)	Pre-session materials (approximately 10 pages) were distributed 3 days before each session, which started with students taking individual RATs (IRATs) using the audience response system (ARS). Intra-team discussions were then held, after which each team took group RATs (GRATs). The use of books, notes, and other materials was prohibited during the RATs.
3) Immediate feedback	IRAT and GRAT scores were available immediately through the ARS, so instructors were able to give quick feedback on the basis of the GRAT results and direct team discussions.
4) Sequencing of in-class problem solving	Five application activities were prepared over a period of 100 minutes. The process was managed with ARS and performed according to the GRAT rules.
5) The 4Ss (significant, same, specific, simultaneous)	All students tackled the same problems simultaneously using the ARS. The instructors were all specialists in particular clinical fields and were able to select significant problems that were solved based on specific evidence.
6) Incentive structure	IRAT and GRAT scores were scored in our institution's secure server. Total IRAT and GRAT scores were used for grading purposes.
7) Peer review	We did not use peer-review methods in 2011.

group RAT (GRAT), which consisted of the same questions, together with the other members of their team. The ARS allowed us to obtain the IRAT and GRAT scores immediately and show the results on a large screen. Instructors could then use the ARS to monitor intra- and inter-team discussions, giving immediate feedback based on "the 4 S's principle" (significant, same, specific, simultaneous) they had learned about at the faculty development workshop. All students have to tackle the "same" problems "simultaneously" using the ARS. The instructors were all specialists in particular clinical fields and were able to select "significant" problems that were solved based on "specific" evidence. In some sessions, a guest speaker from the Department of Basic Biomedical Sciences attended to activate discussions. After all of the sessions had been completed, the RAT scores were tallied and used for grading. We did not use peer-review methods in 2011.

2. Assessment of RAT Results

IRAT and GRAT scores were stored on NMS's secure server, and the total scores of all 15 sessions were converted into percentages for assessment purposes.

3. Questionnaire Survey (Table 2)

A questionnaire was administered at the beginning of the TBL course (after the 1st TBL session), in the middle (after the 8th session), and at the end of the course, in which students were required to answer the same 5 questions using a 5-point scale with 1 indicating the lowest level of agreement and 5 the highest. At the end of the TBL course, the instructors were also asked to complete a separate questionnaire.

Results

1. Assessment of RAT Results

The mean individual total IRAT and GRAT scores

Table 2 Questionnaires for students and instructors

Questionnaire for students
Q1: Did you do the session preparation work?
Q2: Did your preparation contribute to your team's GRAT score?
Q3: Did you actively participate in the team discussion?
Q4: Did the application activities further your understanding of the topic?
Q5: Do you think TBL is a useful learning method?
Q6: Which of the following learning methods do you find effective (multiple choices are possible)? TBL, PBL, lectures, self-learning
Questionnaire for instructors
Q1: Do you think TBL is a useful educational strategy?
Q2: Do you think TBL can be used as a substitute for PBL?
Q3: Do you think students prepared adequately for each session?
Q4: Did you find that preparing for each session was hard work?
Q5: Do you think TBL can be used beneficially to supplement traditional lecture courses?
Q6: Do you think the ARS is a useful tool in medical education?
Q7: Which of the following do you think make TBL useful (multiple choices are possible)? encourages students to prepare, RATs, ability to monitor students' understanding in real time, efficient use of faculty members, efficient use of time

Table 3 Questionnaire for students: results

Questionnaire items (see Table 2 for full questions)	mean values ± SD		
	beginning of course	middle of course	end of course
Q1: Preparation	3.39 ± 0.99	3.33 ± 1.03	3.2 ± 1.06
Q2: Contribution to GRAT score	3.45 ± 0.92	3.73 ± 0.97	3.41 ± 0.84
Q3: Contribution to team discussion	3.92 ± 0.9	4.05 ± 0.91	3.89 ± 0.92
Q4: Contribution of application activities to understanding	3.68 ± 1.03	3.63 ± 1.06	3.44 ± 0.98
Q5: Usefulness of TBL	2.87 ± 1.19	3.17 ± 1.21	2.81 ± 1.23

were 70.9 ± 7.84 and 80.8 ± 5.41 (mean ± SD), respectively. The total grade of TBL, (IRAT scores + GRAT scores) × 1/2, was 75.8 ± 6.12.

2. Questionnaire Survey of Students

The questionnaire response rate among the students was 94%; the results are shown in **Table 3**. The mean scores on Q1, which concerned the students' level of preparation, were 3.39 ± 0.99 (mean ± SD) at the beginning of the course, 3.33 ± 1.03 in the middle, and 3.2 ± 1.06 at the end. The corresponding figures for Q4 (about the application activities) were 3.68 ± 1.03, 3.63 ± 1.06, and 3.44 ± 0.98, and for Q5 (about the usefulness of TBL) they were 2.87 ± 1.19, 3.17 ± 1.21, and 2.81 ± 1.23. Q6 asked students which learning methods they found most effective from among TBL, PBL, lectures, and self-learning. Seven percent selected TBL at the beginning of the course, 14% in the middle, and 11% at the end. The corresponding figures for PBL were 20%, 19%, and 21%, for lectures 33%, 28%, and 29%, and for self-learning 40%, 39%, and 39% (**Fig. 2**).

3. Questionnaire Survey of Instructors

Eighteen of the 20 instructors answered the questionnaire; the results are shown in **Table 4**. Q1 concerned the usefulness of TBL and attracted a mean rating of 3.72 ± 0.73. The mean score for Q2 (whether TBL could substitute for PBL) was 3.12 ± 0.81. That for Q4 (about how burdensome preparation was for instructors) was 4.44 ± 0.5, that for Q5 (about the applicability of TBL to traditional lecture courses was 3.72 ± 0.87, and that for Q6 (about the usefulness of the ARS) was 4.28 ± 0.87.

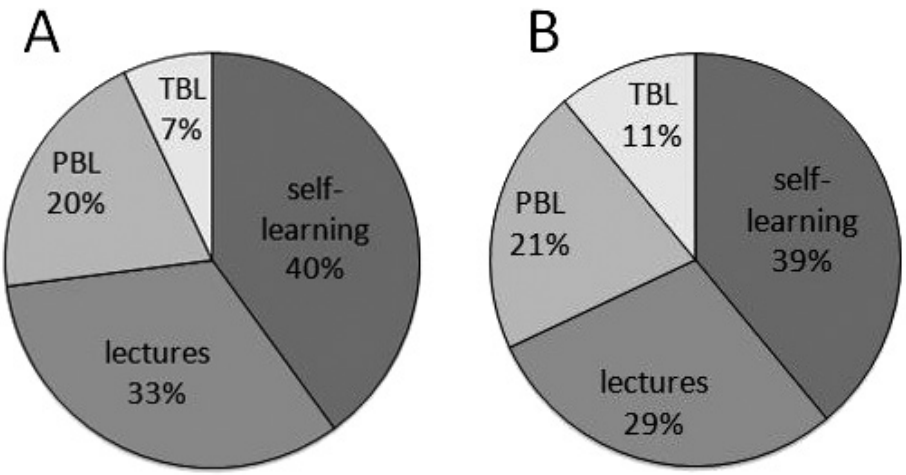

Fig. 2 Students' preferred learning methods
A: at the beginning of the TBL course, **B**: at the end of the TBL course

Table 4 Questionnaire for instructors: results

Questionnaire items (see Table 2 for full questions)	mean values ± SD
Q1: Usefulness of TBL	3.72 ± 0.73
Q2: TBL as a substitute for PBL	3.12 ± 0.81
Q3: Student's preparation	3.61 ± 1.01
Q4: Burden of preparation on instructors	4.44 ± 0.5
Q5: Use of TBL as supplement to lecture courses	3.72 ± 0.87
Q6: Usefulness of the ARS	4.28 ± 0.87

Discussion

The guidelines of Haidet et al include a "peer review process" for TBL group activities. We did not include this in our course in 2011, because it is a process that is unfamiliar to most Japanese. However, we are planning to introduce peer review into the course next year, in accordance with the reported method[1,2]. All instructors were familiar with the "4 S's principle," and it was properly used to prepare class materials. The instructors were also all specialists in particular clinical fields, and they used their specific knowledge to prepare materials that would activate intra- and inter-team discussions and bring out the best from each team. However, in 2011 we had to prepare 15 sessions in three months, so the quality of class materials might have varied somewhat. In the questionnaire for instructors, the mean score for the question about how burdensome they found preparation was 4.44 ± 0.5. Preparing RATs and application activities was a heavy burden for the instructors, as reflected in their questionnaire rating of the usefulness of TBL (mean score: 3.72 ± 0.73). However, they also recognized the benefits of TBL (in, for example, encouraging learners to prepare for sessions) and the usefulness of RATs and the ARS. On the other hand, the students' rating of the usefulness of TBL in the middle of the course was 3.17 ± 1.21, which declined to 2.81 ± 1.23 at the end of the course. Clearly, it was not easy for the students to maintain high levels of motivation throughout the 15 sessions. Nevertheless, we observed active discussions among the teams even in some of the later sessions when the instructors had prepared well-designed class materials. We gained the impression that the quality of materials in the application phase was key to activating learner motivation.

The ARS, which has recently started to be exploited successfully in medical education, including TBL sessions[7,8], allowed us to give immediate feedback to all groups simultaneously in large classrooms. For almost all of the instructors, it was

the first time they had used the ARS, and it helped them recognize the importance of interactive classes. They also appreciated the fact that they could monitor students' understanding in real time, and they rated the system highly in the questionnaire: 4.28 ± 0.87. Conversely, the students did not appreciate the ARS, because they recognized that the results could be easily used for grading. The discrepancy between the instructors' and students' evaluations of the ARS was perhaps inevitable. The mean total scores on IRATs and GRATs were 70.8 ± 7.68 and 80.8 ± 5.41, respectively. The improvement in the group scores over the individual scores demonstrates that the difficulty levels of the RATs were probably appropriate. From these scores and the results of the students' questionnaire, we can see that the process of preparation, intra-team discussion and individual contribution to GRAT is conducive to learning. However, the use of RAT scores for grading is an issue that needs further consideration.

The student's preferred learning methods, as stated in order of preference at the end of the course, were self-learning (39%), lectures (29%), PBL tutorials (21%), and TBL (11%). Our students thus showed a clear preference for PBL over TBL, stating that PBL allows them to study what they want to study. However, the preference rates for both TBL and PBL increased during the course **(Fig. 2)**, showing that students had perhaps begun to recognize the significance of self-directed learning through the TBL course. Of the instructors, 39% agreed that TBL would be a good substitute for PBL because of the greater burden that PBL management puts on them. This was another area in which discrepancies between the instructors' and students' evaluations were found.

In their free written comments in the questionnaire, many students complained about the mismatch between the TBL contents and the subjects of ongoing examinations. Perhaps because students were required to prepare both for TBL sessions and examinations in different fields at the same time, their scores on the questionnaire item concerning preparation was rather low (3.2 to 3.39). This problem might well be the most significant reason for the discrepancy between the students and instructors in their evaluations of TBL itself.

Although we are careful to schedule the PBL and TBL courses around the regular lectures given at our institution, the main lectures are organized by another committee, and examinations are given with no consideration of the PBL and TBL course schedules or grades. This is a problem in urgent need of solution, as it undermines our whole undergraduate medical program. TBL is a teacher-oriented yet interactive form of education that can be adapted to provide good instruction in individual subjects, and scores acquired in TBL programs should count significantly toward a student's overall grade in any particular subject[9]. In this study, the instructors did not rate the application of TBL to traditional lecture courses particularly highly: the mean score for this item in the questionnaire was 3.72 ± 0.87. This is probably because many of the instructors responding to the questionnaire also gave regular lectures and regarded dealing with TBL in addition as a burdensome task.

PBL has been demonstrated to have a negative effect on knowledge acquisition, but to have a positive effect on knowledge application[10,11]. Therefore, using TBL as a preparatory activity for PBL so that students can acquire enough knowledge to engage in self-directed learning may be an effective strategy. Applying PBL and TBL across the entire undergraduate medical program would require large-scale changes in curriculum design[12], but a well-devised combination of large classroom lecture, PBL, and TBL would improve both motivation and understanding among students, while at the same time increasing faculty satisfaction.

Conflicts of interest statement: The authors have no conflicts of interest to declare.

Acknowledgements: The authors would like to offer their sincere thanks to the following instructors who took part in the TBL program: J. Hayakawa, M. Takano, H. Yamaguchi, K. Fujita, C. Takaku, Y. Kuwahara, H. Narasaki, T. Fukazawa, M. Miyauchi, I. Kikuchi, M. Goto, T. Masuno, and Y. Goto. We would also like to thank H. Doshida for his efficient administrative support.

References

1. Team-based learning: a transformative use of small groups (Michaelsen LK, Knight AB, Fink LD, eds), 2002; Greenwood, Westport, CT.
2. Team-based learning: a transformative use of small groups in college teaching (Michaelsen LK, Knight AB, Fink LD, eds), 2004; Stylus Publishing, Virginia.
3. Haidet P, Levine RE, Parmelee DX, et al.: Guidelines for reporting team-based learning activities in the medical and health sciences education literature. Acad Med 2012; 87: 292–299.
4. Haidet P, O'Malley KJ, Richards B: An initial experience with team learning in medical education. Acad Med 2002; 77: 40–44.
5. Thompson BM, Schneider VF, Haidet P, et al.: Team based learning at ten medical schools: two years later. Med Educ 2007; 41: 250–257.
6. Abdelkhalek N, Hussein A, Gibbs T, Handy H: Using team-based learning to prepare medical students for future problem-based learning. Med Teach 2010; 32: 123–129.
7. Okubo Y, Ishiguro N, Suganuma T, et al.: Team-based learning, a learning strategy for clinical reasoning, in students with problem-based learning tutorial experiences. Tohoku J Exp Med 2012; 227: 23–29.
8. Pileggi R, O'Neill P: Team-based learning using an audience response system: An innovative method of teaching diagnosis to undergraduate dental students. J Dent Educ 2008; 72: 1182–1188.
9. Thomas PA, Bowen CW: A controlled trial of team-based learning in an ambulatory medicine clerkship for medical students. Teach Learn Med 2011; 23: 31–36.
10. Neville AJ: Problem-based learning and medical education forty years on. Med Princ Prac 2009; 18: 1–9.
11. Dochy F, Segers M, Van den Bossche P, Gijbelo D: Effects of problem-based learning: a meta-analysis. Learn Istr 2003; 13: 533–568.
12. Fujikura T: Deliberate unborn medical education through the process of reviewing PBL. Nichiidai ikaishi (Japanese) 2012, in press.

(Received, June 10, 2012)

(Accepted, September 24, 2012)