Team-Based Learning, a Learning Strategy for Clinical Reasoning, in Students with Problem-Based Learning Tutorial Experiences

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Acquiring clinical reasoning skills in lectures may be difficult, but it can be learnt through problem-solving in the context of clinical practice. Problem finding and solving are skills required for clinical reasoning; however, students who underwent problem-based learning (PBL) still have difficulty in acquiring clinical reasoning skills. We hypothesized that team-based learning (TBL), a learning strategy that provides the opportunity to solve problems by repeatedly taking tests, can enhance the clinical reasoning ability in medical students with PBL experiences during the pre-clinical years. TBL courses were designed for 4th year students in a 6-year program in 2008, 2009, and 2010. TBL individual scores, consisting of a combination of individual and group tests, were compared with scores of several examinations including computer-based testing (CBT), an original examination assessing clinical reasoning ability (problem-solving ability test; P-SAT), term examinations, and Objective Structured Clinical Examination (OSCE). CBT, OSCE and P-SAT scores were compared with those of students who learned clinical reasoning only through PBL tutorials in 2005, 2006, and 2007 (non-TBL students). Individual TBL scores of students did not correlate with scores of any other examination. Assessments on clinical reasoning ability, such as CBT, OSCE, and P-SAT scores, were significantly higher in TBL students compared with non-TBL students. Students found TBL to be effective, particularly in areas of problem solving by both individuals and teams, and feedback from specialists. In conclusion, TBL for clinical reasoning is useful in improving clinical reasoning ability in students with PBL experiences with limited clinical exposure.

Keywords: clinical reasoning; medical education; medical students; problem-based learning; team-based learning

Team-based learning (TBL) is a particular instructional strategy that is designed to support the development of high performance learning teams and to provide opportunities for these teams to engage in significant learning tasks in the same educational circumstance as ordinary lectures in large classrooms (Michaelsen et al. 2002, 2004). Individual members of the team have a better understanding of the material and the team becomes capable of solving challenging and complex problems through repeated reading assignments, the Individual Readiness Assurance Test (IRAT), intra-team discussion, the Group Readiness Assurance Test (GRAT), inter-team discussion and feedback from instructors. In TBL, learners experience in-class and out-of-class activities through preparation, application, and assessment phases.

Our students study basic science, basic medicine, and clinical medicine through a hybrid of lectures, problem-based learning (PBL) tutorials, and practical laboratory training in the first 4 years of the 6-year medical program (Kozu 1997; Yoshioka et al. 2005; PBL Tutorial Committee 2009). We strategically integrated TBL, using clinical cases for 4th year students with abundant PBL experience, to
determine whether this would improve students’ clinical reasoning ability. Assumed advantages of TBL in learning clinical reasoning are that students learn how to unite their knowledge into clinical decision-making and prioritize possible solutions through individual thinking and inter-team and intra-team (entire class) discussions. Our 4th year students are given the opportunity to practice identifying problems, small-group discussions, and solving problems through PBL tutorials for the first three and a half years (Yoshioka et al. 2003, 2005). We provide PBL tutorials to students as a student-centered learning strategy focusing on developing skills for problem-finding and problem-solving both individually and in small groups. In comparison, we designed TBL as a type of lecture whereby the role of instructors is to manage the overall learning process and direct students in clinical thinking, such as by providing reading assignments as out-of-class activities, and guiding students on how to solve clinical problems in a big classroom as in-class activities. PBL tutorials with well-designed clinical scenarios are a good strategy for clinical reasoning (Maudsley and Strivens 2000), but there are limitations for students who do not have extensive clinical experiences to acquire clinical thinking ability in only a small group study. Although our students have early clinical exposure, such as observing out-patient clinics, community health care, and nursing in the pre-clinical year, their experiences are limited when making diagnoses and choices for best treatment by themselves. PBL tutorials might have a limitation in inducing students to make practical and timely clinical judgments. We hypothesized TBL to be a better strategy for clinical decision-making in students with PBL tutorial experiences but limited clinical experiences, with an advantage of inter-team discussion and feedback from clinical specialists.

The purpose of this study is to establish effective TBL courses for medical students to improve clinical reasoning ability. In order to investigate the effectiveness of TBL in students, we assessed students’ clinical reasoning abilities compared with those of non-TBL students, by comparing TBL scores with to other examination scores, and analyzing student comments on TBL especially in comparison to comments on PBL tutorials.

**Subjects and Methods**

In 2008, 2009, and 2010, all 4th year students at Tokyo Women’s Medical University School of Medicine participated in 2 TBL courses each year. Students were given progressive PBL tutorials continuously for three and a half years, including an introductory tutorial, a learning issues-oriented tutorial, and a clinical problem-oriented tutorial (Fig. 1). We designed TBL courses for students to improve clinical reasoning ability, to act as a bridge between progressive tutorials and clinical practice as part of Introduction to Clinical Medicine (ICM). TBL courses were conducted using the modified approach (Fig. 2), where students studied before a class session utilizing the given learning objectives and limited information related to the case, such as a chief complaint. In class, two instructors usually ran the session; one chaired the TBL and the other gave feedback on the content as a specialist. Students first took the individual readiness test (IRAT) using the response analyzer system developed for TBL which can accept up to 20 continuous question-answering, then had an intra-team discussion about the test with 6 to 7 team members, followed by the group readiness test (GRAT) on the same problems. The TBL groups consisted of the same students as the groups for the recent PBL tutorials, meaning that the group members were used to having discussions with each other. Immediate analysis of IRAT and GRAT scores using the response analyzer system was shown on-screen to the entire class consisting of nearly 100 students. Students of the entire class then participated in inter-team discussions conducted by an instructor who acted as a TBL chairperson, followed by some feedback by the same or different instructor, as a specialist in the clinical field. The sessions were designed to navigate students to follow in the clinical step, from making a diagnosis, selecting preferred examinations and treatment, to prognosis and social problems. A
TBL in Students with PBL Tutorial Experiences

25

A TBL session in a 105-minute class consisted of two to three cycles consisting of IRAT, intra-team discussion, GRAT, inter-team discussion, feedback, and application, and a TBL course was composed of two or three TBL sessions, solving problems pertaining to one clinical case. At the end of a TBL course, students assessed their achievements, including peer evaluations. Individual scores in TBL were calculated based on results of IRAT and GRAT scores and peer evaluation in the subscribed method (Michaelsen et al. 2004). In brief, individual scores were the sum of IRAT scores and adjust group scores for the sum of individual peer evaluation, which is given to each student by other group members. Each student was given a total of 100 points for peers and gave points to others for their contribution in group activities.

Individual TBL scores were compared with individual scores of several examinations, which assess clinical reasoning ability in part. These include: (i) a nationwide computer-based test (CBT), a test designed by the Japanese Common Achievement Test Organization (CATO) composed of 320 items, including multiple choice questions having many response choices, on basic knowledge; extended matching items on basic science and diagnosis speculating the pathophysiology and symptoms; and multi-step questions on reasoning skills in clinical context, (ii) an originally designed computer-based and case-oriented examination assessing clinical reasoning ability test (problem-solving ability test; P-SAT) consisting of multi-step questions including medical interviews, physical examinations, laboratory examinations, and clinical judgment formally implemented in 2007. The test measures clinical reasoning skills needed to prioritize the order in medical interview questioning, differential diagnosis, choice of laboratory tests, and choice of treatment; (iii) term examinations for each subject evaluating knowledge through multiple choice and short essay questions, (iv) PBL tutorial evaluations by tutors on knowledge and learning attitudes including problem finding, reasoning, and solving skills by tutors, (v) a paper examination for clinical diagnostics, and (vi) Objective Structured Clinical Examination (OSCE) designed and operated by CATO assessing clinical competencies in basic clinical skills and attitude. In addition, CBT and P-SAT scores were compared among students with or without TBL experience. In 2005, 2006, and 2007, students studied clinical reasoning through PBL tutorials only, whereas students in 2008, 2009, and 2010 experienced both PBL and TBL tutorials.

Comparison of individual TBL scores with the above (i) ~ (iv) examinations was analyzed by correlation analysis and Bartlett’s test. Comparison of students’ CBT and OSCE scores in non-TBL groups (2005, 2006, and 2007) and in TBL groups (2008, 2009, and 2010) and as well as comparison of students’ P-SAT scores in 2007, 2008, 2009, and 2010 were analyzed by analysis of variance (ANOVA) and post hoc tests.

An analysis of students’ comments on TBL and other learning methods was also conducted.

Results

All students (100%) in each class attended TBL courses (2008, 104 students; 2009, 97 students; 2010, 106 students) in spite of the fact that 5~8% of the students were late for sessions. Students were more actively engaged in the sessions, with high participation in the inter-group discussion, compared with lectures.

CBT scores for clinical reasoning ability in students who took TBL courses in 2008, 2009, and 2010 (TBL students) were significantly higher than those who did not take TBL courses in 2005, 2006, and 2007 (non-TBL students) (Fig. 3A, non-TBL, n = 298, 62.7 ± 14.6, TBL, n = 308, 69.3 ± 11.4) (p < 0.0001) as well as total CBT scores (Fig. 3B), non-TBL, n = 298, 76.2 ± 7.5, TBL, n = 308, 44.5 ± 7.4) (p < 0.05) and OSCE scores (Fig. 3C), non-TBL, n = 297, 87.2 ± 3.9, TBL, n = 308, 89.1 ± 4.0) (p < 0.0001). Our original P-SAT scores were significantly higher in students with TBL activities compared with those students without TBL (Fig. 3D), 2007 (n = 105, 66.2 ± 7.6) vs 2008 (n = 104, 69.9 ± 4.1) (p < 0.0001), 2007 vs 2009 (n = 97,
68.1 ± 4.7) (p < 0.01), 2007 vs 2010 (n = 106, 75.7 ± 3.6) (p < 0.0001). For the P-SAT, students only answer 30 questions selected from 150-pooled questions, of which about 20 questions are evident of the percentage of correct answers and identification index. These are used for P-SAT scoring and the remaining 10 questions are used as a trial for future P-SAT.

Individual TBL scores did not correlate with CBT, P-SAT, term paper examinations, PBL tutorials, paper examinations for diagnosis, or OSCE scores (Table 1, data shown for 2009 only).

However, a qualitative study via questionnaire survey indicated that many students gave positive comments on TBL evaluation of gradual settings in clinical problem-solving, inter-group discussions (Table 2), and quick feedbacks by instructors. Students evaluated that TBL was beneficial in the areas of problem-solving both by individuals and as a team, learning process of clinical problem-solving through IRAT, GRAT, and discussion, increased awareness of different decisions and reasoning of other teams, learning clinical decision-making in a short period of time relevant to clinical settings, and quick feedback from instructors in areas students had difficulty understanding. On the other hand, students disliked peer-evaluation and felt that PBL
TBL in Students with PBL Tutorial Experiences

Table 2. Student comments on TBL.

TBL is useful for learning clinical reasoning because:
- problem-solving is repeatedly pondered by both the individual and team
- case presentation according to the process of reasoning
- practical setting for decision-making in a short period of time
- can experience diversity in clinical reasoning through team and inter-team (entire class) discussions
- helpful, quick feedback from instructors

PBL tutorial is better because:
- concentrates on individual interests
- freedom in problem finding
- open and longer discussions

Dislike of peer-evaluation for TBL

tutorials were better that they allow more freedom in problem-finding, concentration in personal interests, and open and longer discussions.

For many students, the total number of hours spent on self-learning for TBL per day was 1 to 2 hours, which is the same for PBL tutorials (Fig. 4A). More than half of the students selected ‘discussion skills’ as the top competency achieved through TBL (Fig. 4B). When asked which method was most effective in increasing their understanding learning objectives, the majority answered ‘self-learning’ or ‘PBL tutorials’, whereas only 4% selected TBL (Fig. 4C). However, 16% of students recalled TBL to be the ‘most impressive’ learning method to entrench the learning objectives (Fig. 4D).

Discussion

In this study, we set out to determine whether TBL can enhance the clinical reasoning ability in students. The comparisons between students who underwent TBL and those who did not, clearly demonstrated that TBL improved the clinical reasoning ability measured by multiple assessment tools. The process of clinical reasoning consists of patient or situation characteristics, prior knowledge, problem representation, evaluation, information gathering, and actions such as treatment and management (Charlin et al. 2000; Gruppen and Frohna 2002; Bowen 2006). Students who have limited clinical exposure need a clear direction to start thinking clinically. We believe that our TBL system enables
students to gradually learn the clinical-thinking process by giving learning objectives for readiness, opportunities for individual and small-group problem-solving, and feedback.

Implementation of TBL among students with PBL tutorial experience is unique to our curriculum. An abundant experience in PBL tutorials may foster self-learning and group-dicussions in TBL sessions. There has been some literature introducing TBL in medical education as an effective learning strategy (Haidet et al. 2002; Kuhne-Eversmann et al. 2008; Letassy et al. 2008; Conway et al. 2010; Koles et al. 2010; Parmeelee and Michaelsen 2010). Some medical schools have implemented TBL instead of PBL tutorials. There has been a report on a TBL study designed to prepare students for future PBL tutorials (Abdelkhalek et al. 2010). Our students were familiar with having discussions with one another, which quite uncommon in Japanese medical schools. However, younger students who are inexperienced with self-learning and discussions may need more time to adapt to TBL.

In our study, TBL improved student CBT scores for clinical reasoning ability, OSCE scores, and P-SAT scores compared with non-TBL students. Clinical reasoning ability may be evaluated by clinical structured interviews (Eva et al. 2004 a, b) or mini CEX (Norcini et al. 2003). However, for students with limited clinical experience, clinical reasoning ability obtained through TBL can only be evaluated using a similar strategy. CBT for clinical reasoning ability and our P-SAT are structured in a process similar to that of TBL, including clinical interviews, physical examinations, laboratory data, imaging procedures, diagnosis, treatment, and social problems on the computer screen. Students who experienced TBL on clinical thinking procedures and discussed answers through intra- and inter-group discussions performed better in these examinations. The reason for this improvement in OSCE scores of students with TBL could be explained by the fact that students obtained more clinical sense of patients’ safety and emotions from clinical interviews and clinical examinations.

One limitation of this study lies in the interpretation of the P-SAT results and the fact that this examination was formally implemented in 2007. Thus, data for non-TBL students are obtained from one class. Students’ self-learning hours were similar compared with PBL, but many students expressed positive comments on TBL especially for repeated problem-solving processes by the individual, team, and entire class, and clinical instructor’s feedback. PBL can provide a deeper study for the individual and group, whereas TBL can provide repeated practice for problem-solving processes to students on a variety of issues.

We used the response analyzer system for IRAT and GRAT. To our knowledge, this system has been used for the first time in TBL. There has been a report on the benefits of using an audience response system in lectures (Pileggi and O’Neill 2008). Our system enabled real-time presentation of IRAT and GRAT results of students’ accelerated inter-group discussions and motivation shifting to acquiring clinical decision-making skills. Students actively asked specialists questions about appropriate selections for solving clinical problems. Although instructors can manage to stimulate smooth and active TBL sessions, we found the response analyzer system to be useful during TBL sessions.

TBL can be adapted in basic medicine (Nieder et al. 2005; Vasan et al. 2009), but since we found TBL to be an efficient educational strategy for clinical reasoning ability. We believe TBL can allow students to experience more realistic decision-making by using actual clinical cases compared with PBL tutorials. TBL can also be used as inter-professional education (Rider and Brashears 2006), which medical students will face in different clinical fields. We are planning to develop TBL by applying it to more complicated clinical problems, including ethical and global issues, which need more discussion and consensus in a large class.

In conclusion, students with abundant PBL experience adapted well to the TBL we designed for clinical reasoning. Establishing an educational system and faculty development to improve TBL will help enrich the outcome.

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Conflict of Interest

The authors have no conflicts of interest to declare.

References


